Volume 5 February, 1926 Number 2

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Published Monthly by the American Welding Society
33 West Thirty-ninth Street, New York

American Welding Society

OFFICERS FOR 1925-26

A. G. OEHLER, *President*
C. A. MCCUNE, *Treasurer*
M. M. KELLY, *Secretary*
T. A. WRY, *Vice-President*
J. D. CONWAY, *Vice-President*
STUART PLUMLEY, *Vice-President*
GEORGE BIRD, *Vice-President*
N. A. WRIGHT, *Vice-President*

DIRECTORS

(Officers listed above are also members of the Board of Directors)

Term Expires 1926	*Term Expires* 1927	*Term Expires* 1928	*Section Representatives*
C. A. ADAMS	J. H. DEPPELER	JAMES BURKE	C. W. BATES
A. M. CANDY	A. S. KINSEY	J. W. MEADOWCROFT	J. C. BENNETT
C. J. HOLSLAG	E. M. T. RYDER	H. A. WOOFTER	H. P. DOUD
H. S. SMITH	W. A. SLACK	S. W. MILLER	H. D. KELLEY
C. A. MCCUNE	T. F. BARTON	E. H. EWERTZ	J. C. LINCOLN
			J. W. MORRISSEY
			H. M. HOBART
			W. A. SLACK
			G. W. SWAN
			L. G. HICKS
			A. E. GAYNOR

PAST-PRESIDENTS

C. A. ADAMS (1919-20)
J. H. DEPPELER (1920-21)
S. W. MILLER (1921-22)
C. A. MCCUNE (1922-23)
T. F. BARTON (1923-24)
E. H. EWERTZ (1924-25)

CHAIRMEN, STANDING COMMITTEES

Executive—A. G. OEHLER
Finance—C. A. MCCUNE
By-Laws—A. M. CANDY
Meetings and Papers—P. W. SWAIN
Membership—J. J. FLAHERTY

W. SPRAGEN, *Editor, Journal*

American Bureau of Welding

(RESEARCH DEPARTMENT OF SOCIETY)

OFFICERS

C. A. ADAMS, *Director*
H. L. WHITTEMORE, *1st Vice-Director*
A. D. RISTEEN, *2nd Vice-Director*
WM. SPRAGEN, *Secretary*

CHAIRMEN, RESEARCH COMMITTEES

Electric Arc Welding—H. M. HOBART
Gas Welding—S. W. MILLER
Welded Rail Joints—G. K. BURGESS
Welding Wire Specifications—C. A. MCCUNE
Pressure Vessels—H. L. WHITTEMORE
Thermit Welding—J. H. DEPPELER

JOURNAL

OF THE

AMERICAN WELDING SOCIETY

Copyright 1926, by the American Welding Society,
33 West Thirty-ninth Street, New York.

Subscription $10.00 per year to United States. $11.00 to Canada. Libraries $5.00.
Back numbers, per copy: Members, $0.50; Non members, $1.00.

The Society is not responsible for any statement made or opinion expressed in its publications. Permission is given to reprint any article after its date of publication, provided proper credit is given.

Volume 5 **FEBRUARY, 1926** **Number 2**

TABLE OF CONTENTS

Society and Related Activities **Page**

Annual Meeting 3
Welded Rail Joints 3
Fall Meeting 3
Pressure Vessels 4
Change in By-Laws 4
Section Activities 5
Employment Service Bulletin 6

Technical Papers, Items and Reports

Procedure Control for Oxy-Acetylene Welding Cast Iron Heater Sections.. 7
Welding as a Means of Fabricating Tanks, Vessels and Pipes..... 8
Gold in Welding Process 16
Fusion Welded Pressure Vessels 26
Proposed Code for Welded Vessels..... 26
Specifications for Fusion Welded Tank 60 In. in Diameter and 20 Ft. Long... 37
Selected Bibliography 39
Current Welding Literature 40

SECTION OFFICERS AND HEADQUARTERS

PHILADELPHIA

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

Chairman—P. A. L. Maurhoff, District Manager, Oxweld Acetylene Co.
Secretary—H. E. Hopkins, 709 W. Huntington St., Philadelphia, Pa.

CHICAGO

Monadnock Building, Chicago

Chairman—T. M. Jones, Illinois Steel Co.
Secretary—Stuart Plumley, Editor, Acetylene Journal.

PITTSBURGH

1841 *Oliver Bldg., Pittsburgh*

Chairman—J. D. Conway, Secretary-Treasurer, Railway Supply Mfg. Assn.
Secretary—H. E. Hollis, P. O. Box 681, Pittsburgh, Pa.

NEW YORK

33 *West Thirty-ninth Street, New York*

Chairman—A. E. Gaynor, J. A. Roebling Sons Co.
Secretary—A. F. Keogh, Sound Welding Company.

NORTHERN NEW YORK

General Electric Co., Schenectady

Chairman—W. L. Warner, General Electric Co.
Secretary—W. P. Madden, General Electric Co.

CLEVELAND

2200 *Chester Avenue, Cleveland, Ohio*

Chairman—John H. Thornton, David Lupton Sons Co.
Secretary—R. K. Randall, Dean, Welding School, Cleveland School of Technology.

SAN FRANCISCO

Rialto Building, San Francisco

Chairman—G. O. Wilson, Engineer, Standard Oil Company of California.
Secretary—W. B. Sawyer, Jr., United States Steel Products Company.

LOS ANGELES

P. O. Box 510, Arcade Sta.

Chairman—L. G. Hicks, Standard Oil Co.
Secretary—L. R. Ardouin, U. S. Steel Products Co.

BOSTON

Engineers' Club, 2 Commonwealth Avenue, Boston, Mass.

Chairman—T. A. Wry, General Electric Co., Lynn, Mass.
Secretary—J. W. Morrissey, P. F. McDonald & Co.

WESTERN NEW YORK

509 *Morgan Bldg., Buffalo, N. Y.*

Chairman—Robert Siemer, Allan Mfg. & Welding Co.
Secretary—C. D. Miller, Burke Electric Co., Buffalo, N. Y.

DETROIT

Chairman—H. M. Gould, Assistant General Manager, Dept. of Street Railways, City of Detroit, Mich.
Secretary—C. L. Finch, Detroit Range Boiler and Steel Barrel Co., Detroit, Mich.

AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

Volume 5 FEBRUARY, 1926 Number 2

ANNUAL MEETING

Some novel features have been proposed for the program of the annual meeting, which will be held in New York on April 21 to 23, 1926. The business session is to be condensed and a greater portion of the time devoted to technical sessions. The principal subject under consideration will be a symposium on the design of welded joints, including:

a. Stresses—kinds and amounts.
b. Accessibility and position.
c. Technique.
d. Type of joints.
e. Materials.
f. Thermal considerations.
g. Tightness.
h. Tests.

Several papers will be secured from important industries on this broad subject and these will be printed in advance in order to allow ample time for discussion. Another feature is to be a dinner-theater party to which ladies will be invited. There will be the usual research committee meetings in advance of the business session and an inspection trip to some place of universal interest to the welding fraternity. Other announcements will be made in the complete program, which will be included in the next issue of the Journal.

WELDED RAIL JOINTS

The Welded Rail Joint Committee held a meeting of its Executive Committee in Washington on the afternoon of Feb. 12. On the day preceding this meeting a number of rail joint experts as well as metallurgists examined the specimens broken by the repeated impact testing machine which has been in operation day and night for the past two years.

A comprehensive investigation has been made by the Committee on the subject of welding wire for seam welded joints. Half inch flat plates were welded up using a number of different wires by expert welders in the metal arc, carbon arc "hand feed" and carbon arc "rod in position" systems. These plates were cut up in test specimens and tested in tension and bending, according to the American Welding Society specifications. The results of these tests were analyzed at the meeting.

A scientific investigation is proposed by the Committee using the electrical recording strain gage developed by the Bureau of Standards called the telemeter for measuring stresses in different parts of rail joints caused by different service conditions.

FALL MEETING

The next fall meeting of the American Welding Society will be held in Buffalo at the headquarters of the Western New York Section. In conjunction with this meeting, an international welding exhibition is planned which will include the greatest collection of welding exhibits ever gotten together under a single roof. "Put me off at Buffalo" is the slogan proposed by the enthusiasts of the Western New York Section. Although the exact dates have not been announced, the meeting will be held some time in the middle of November. Make your plans to attend.

MEMBERSHIP

In the last issue of the Journal there was published a list of new members secured during the last few months. Preceding this list there was given an "honor list" of the people who secured these new members. It is expected that every member of the Society will secure at least one new member each year. This is considered a part of their membership duties. In this connection, the Secretary of the Society stands ready to offer assistance upon request by furnishing suitable literature, application blanks, sample copy of the Journal and a membership directory.

PRESSURE VESSELS

The American Welding Society and the A. S. M. E. will cooperate in carrying out a scientific investigation in the field of unfired pressure vessels. The testing work is to be done at the Bureau of Standards and at several selected university laboratories.

All the details of the program have not been settled as yet but it will undoubtedly require the test to destruction of a large number of tanks to settle various points dealing with design, effect of vibration, effect of annealing and adaptability of welding for large tanks and for heavy materials. Many fundamental investigations will be carried out at the same time to yield information as to fatigue properties of welded joints, their ability to meet service conditions under high temperatures, welding wire and qualities of steel to be welded.

The exact form of cooperation with the Mechanical Engineers has as yet not been determined. National Research Council will be asked to sponsor the investigation and to act as treasurer for the funds. The investigation will be financed on a cooperative basis so that the burden on any one company will not be very great and the results of the entire investigation will accrue to the benefit of the individual cooperators.

CHANGES IN BY-LAWS

The following revisions have been recommended by the By-Laws Committee and approved by the Executive Committee, the Board of Directors and by a majority of the members of the Society. They have, therefore, been adopted.

Revised Sections.

Article I
Section 2

Class D—Operating Members, *residing in the United States, Canada and Mexico,* who are welders or cutters by occupation without the right to vote or to hold office excepting in sections as may be provided for by the By-Laws of the Section.
Annual Dues $5.00

Class D—Operating Members, *residing outside of the United States, Canada and Mexico,* who are welders or cutters by occupation without the right to vote or to hold office.
Annual Dues $10.00

Note: This amendment was recommended to meet the additional cost of supplying foreign members with Journals and other literature.

Article I, Section 2

Class F—Student Members, who are actually in attendance at any one of the recognized colleges and approved trade schools without the right to vote or to hold office except in sections as may be provided for by the By-Laws of the Section.
Annual Dues $2.50

Note: This addition was proposed as a means of securing the interest of students at colleges, etc.

Article II
Section 1

Class D (resident) members.....$5.00
Class D (foreign) members....10.00
Class F members 2.50

Article III

Sect. 3. The American Welding Society will return to each section fifty per cent of all membership fees received from members enrolled in any section except in the case of *student members, where the entire fee is to be retained by the Society.*

Article IV

Sect. 1. The officers of the Society shall be a *President, six Vice-Presidents,* a Secretary, a Treasurer and a number of directors as herein provided. All officers and directors must be members of the Society.

Sec. 3. A *senior Vice-President residing in the vicinity of headquarters shall be elected by the Society for a term of one year.*

The United States shall be divided into five geographical divisions and *one Vice-President shall be elected from each for a term of two years.* The geographical divisions shall be known as New York and New England Division, Middle Eastern Division, Middle Western Division, Southern Division and Pacific Coast Division.

Vice-Presidents shall not be eligible for immediate reelection *to the same office.*

Note: These amendments were recommended to provide for someone to act in the absence of President.

Article V

Sect. 4. The five Vice-Presidents shall be the official representatives of the Society in the Divisions so elected. They are responsible for the general promotion of the Society in their Divisions, that is, for the activities of the present sections and the organization of new sections.

They are expected to attend as many meetings of sections in their Divisions as they can conveniently.

Note: This amendment is in accordance with proposed change in Art. IV.

SECTION ACTIVITIES

Chicago

The February meeting of this Section will be held on the 5th. Mr. George A. Ellinger of the Page Steel and Wire Co., Monessen, Pa., will present a paper on "Metallurgy of Welds."

Pittsburgh

At the December meeting, held on the 11th, Mr. G. O. Carter, Consulting Engineer of the Linde Air Products Company, presented a paper on "Design for Welding." The January meeting was held on the 15th. Mr. R. E. Kinkead of the Lincoln Electric Company presented a paper on "Some Interesting Characteristics of the Electric Arc." The February meeting was held on the 12th, at which Mr. S. W. Miller, Consulting Engineer of the Union Carbide and Carbon Research Laboratories, presented a paper on the "Oxy-Acetylene Welding of Copper," illustrated by lantern slides. A special feature of this evening was to be a demonstration by Mr. O. L. Gilbert, representative of the Furmanite Corporation on the use of Furmanite Leak Sealing Equipment in stopping a leak in a steam line under pressure.

Boston

The January meeting of this Section was held on the 29th, at which time Mr. W. E. Swift of the American Brass Company presented a moving picture, "From Mine to Consumer—The Story of Anaconda," and also a paper on "The Welding of Non-Ferrous Metals." The February meeting was held on Feb. 19 at the Boston Trade School, at which time Mr. E. E. Thum, Research Engineer of the Oxweld Acetylene Co., presented a paper on "Proper Selection and Testing Materials for Welding." A special demonstration of the use of Stellite in surfacing dies and cutting tools was also scheduled for this meeting.

Western New York

Mr. Robert E. Kinkead of the Lincoln Electric Co. delivered a paper on "Gold in Welding" before this Section on Tuesday, Jan. 26.

Cleveland

This Section held its meeting on Jan. 19. Preceding the meeting an enjoyable dinner was served in the main dining room of the hotel. Mr. H. E. Winkleman of the Purox Company, who has had a great deal of practical experience in the field of cast iron welding, was the speaker of the evening.

New York

The February meeting was held on the 16th in the Edison Lighting Institute of the General Electric Co., Harrison, N. J. About sixty members and their guests enjoyed a unique entertainment in witnessing the various lighting exhibits, lectures, demonstrations and moving pictures at this plant. A few of the outstanding features of the meeting were the demonstration of the development of the modern gas filled lamps from the early days of Edison's first experiment to the present standard light. The largest and smallest lamps of the world were also seen. The mysteries of proper lighting of various rooms in a modern house were actually deminstrated as well as the effects of color lighting, combinations of street lighting, etc. These were supplemented by moving pictures and actual demonstrations. The welding paper of the evening was given by Mr. E. Vom Steeg, Jr., of the General Electric Co. on "Arc Welded Jigs and Fixtures." The New York Section is grateful to the General Electric Co. for its courtesy in this connection.

BOUND VOLUMES, 1925

JOURNAL AMERICAN WELDING SOCIETY

NOW READY

Index of Subjects and Authors Included

Price to Members, $5.00—Non-Members, $10.00

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the number Indicated in Each Case and Mailed to Society Headquarters.*

POSITIONS VACANT

V-31. Salesmen and Estimator wanted. Required by one of the largest and best established job welding concerns in New York. Preferably a man who has experience or one who has a fair knowledge of welding, both gas and arc, and who is accustomed to doing business with large service stations and fleet owners.

An interesting proposition will be made to the right man, which assures a good income on a salary and commission basis, to a live wire who can produce. All details will be treated in confidence.

V-32. Experienced welder or welding engineer wanted who has had broad experience in tank welding including bath boiler construction. In our Seamless Division we have decided to develop welding of certain types and styles of containers, and we want experienced man to follow work through various stages including testing.

Services Available

A-39. Acetylene welder desires position. Have had six years' experience in welding and brazing of all metals. Have been connected with the Todd Engineering Co., The Westchester and Lighting Co., and the National Transit Pump and Machine Co. Can give references.

A-40. Welder desires position. Am an expert in oxy-acetylene welding and cutting and can also do thermit welding. Have had seven years' experience in railroad repair shops, one year as pipe line welder, one year as general cast iron welder, one year as general sawmill welder, one year as repair man and brazing of all methods. Understand preheating. Prefer a job in some northern State around Chicago. Can run a shop as welder foreman in either railroad or contract shop. Can inspect welders. Capable of being service demonstrator and salesman.

A-41. Electric welder desires position. Have had 8 years' experience, including repair, machine and boiler work on the Erie R. R. and high pressure vessel and tank work of Standard Oil Co.

A-42. Electric welder desires position. Have had 10 years' experience, including six with the Tide Water Oil Co., three years with Standard Oil and one and one-half years with M. W. Kellogg Co.

A-43. Oxy-acetylene welder desires position. Have had five years' experience and can weld any kind of work, including aluminum.

A-44. Acetylene welder desires position. Have had seven years' railroad shop welding experience and four years' industrial welding. Desire position as Foreman or Supervisor. Have credentials as welder, also as instructor.

Procedure Control for Oxy-Acetylene Welding Cast Iron Heater Sections*

By J. W. Haygood†

The control of procedure is of vital importance to efficient and businesslike methods in the various ramifications of industry. It is necessary in order to produce high quality products at low unit cost, and efficiency engineers are continually on the lookout for better methods and the more efficient application of existing methods.

Into this whole scheme of industry the art of welding has woven itself in such a fashion and to such an extent that the control of procedure in this very important activity is essential. No matter if the work is done in the welding department of a large plant, or in a small job shop in an alley, a good weld is a good weld, and a poor weld is practically as weak as none at all.

Certain fundamental laws must be adhered to if a weld is to be successful. Each step of making such a weld must be controlled. The hit-or-miss method will not work in producing consistently good welds, whether it be in production or reclamation welding. Because of this some sort of guide or procedure control for a welder to follow will aid greatly in achieving that pinnacle of success—consistently satisfactory welds. Such Procedure Controls should give adequate specifications, provide for frequent checks and tests of operators and articles welded, and should contain a guide for doing the job; a "step-by-step" procedure to be followed, yet not so iron bound as to cramp any ingenuity which the operator may exert.

When a broken part is truly welded it is expected to give as efficient service as a new one. Since "a chain is no stronger than its weakest link," any "weak link" in the welding operation must be strengthened if a successful job is to be done. By subjecting the weld and everything that goes toward making it to a Procedure Control slip-shod practices will be minimized.

In order to insure a 100 per cent satisfactory weld the specifications should cover six items:

(A) A check on the welders,
(B) Selection and Inspection of Material,
(C) Design and Layout of the Welded Joint,
(D) Preparation of the Piece for Welding,
(E) Welding Technique (including organization),
(F) Inspection of Welding, and test of completed joint.

It can readily be seen how these specifications are applied to production welding. Each Procedure Control, of course, is unique in itself—no two are just alike; each depends on the work in hand.

*Paper read before meeting of the Chicago Section of the A. W. S., December, 1925.
†Linde Air Products Co.

This is likewise true in reclamation welding, and such Procedure Controls have aided materially in solving problems involving the repair of many types of intricate castings.

In order to see how such a Procedure Control should function in reclamation welding let us apply the Control to the oxwelding of large cast iron heater sections. The welding of these is not a simple application, and because of a lack of understanding and appreciation of certain fundamental principles they have not been uniformly successful. If, however, proper care is taken in the preparation preheating, welding and subsequent annealing, uniform success can readily be obtained.

(A). *A Check on the Welders*

In oxy-acetylene welding cast iron heater sections the first step is to make sure the welding personnel is capable. The foreman and welders should be experienced in cast iron welding, particularly in repairing thin-walled castings. The welder's ability should be ascertained by requiring him to weld test pieces of the same stock as the heater section. Each test piece should then be tested by gripping it in a vise with the weld flush with the jaws and breaking the pieces with a hammer. A satisfactory piece should break outside the weld, or if in it, should exhibit thorough fusion and complete penetration of the weld metal.

(B) *Selection and Inspection of Material*

The heater sections should be inspected for the location of the cracks and the condition of the adjacent metal. To do this the openings are plugged and 20 lb. per square inch hydrostatic pressure applied. The section may also be hammered in the vicinity of the cracks to disclose any smaller fractures. On the basis of this inspection the foreman (if he is in charge of the job) should accept or reject the casting for welding. Inspection may show that reclamation would be impracticable. If accepted the ends of the cracks should be nicked so the welder can see them.

Firebrick and steel wedges (or fireclay biscuits) should be provided for lining up the heater section. A firebrick furnace (or one constructed of discarded cans which have been split open and wired together) is recommended for preheating. This furnace should inclose the entire casting, draft vents being left at the bottom. A cover of asbestos paper, with two strips of angle iron for support, should be available. Charcoal is recommended as a fuel, for it gives a slow even heat.

The furnace should be so constructed that it will be easy to turn the heater section during welding. A crane or two pieces of 1½-in. pipe about 6 ft. long will aid in this.

Facilities should be in readiness to test the completed weld. This test is made by applying a hydrostatic pressure of at least 40 lb. per square inch, and if possible 60 lb. per square inch. These facilities should include plugs and gaskets for stopping the openings,

and where the city water pressure is higher than the above limits, a pressure gage should be provided. Plugs and gaskets can be made from an old automobile inner tube, and a piece of ½-in. boiler plate, the same size discs being cut from both.

While welding, the shop should be free from drafts. In order to aid the welder in doing a good job it would be well to provide him with a long-handled blowpipe, asbestos paper or millboard shield and gloves for heat protection. Cast iron flux and ¼-in. cast iron welding rod of good quality should be used.

(C) *Design and Layout of the Welded Joint*

In all Procedure Controls specifications should be given for beveling, penetration of the weld metal, and reinforcement of the joint. Because of the thinness of the heater section walls no beveling is necessary, complete penetration being secured during the welding operation. Likewise it is not necessary to reinforce such a weld, although care should be taken to see that the weld metal is built up flush with the casting wall surface.

(D) *Preparation of the Piece for Welding*

The casting is first stripped of all fittings, fuse and safety plugs, and the section around the crack then thoroughly cleaned with a wire brush, or grinding wheel, and hammered to remove as much scale and rust from the inside as possible.

In order to equalize the weight, the casting should be supported at six or more points about 6 in. above the preheating furnace floor. Two firebricks placed horizontally one upon the other form suitable supports, the casting being shimmed with (firebrick biscuits) *or* wedges. The casting should always be lined up so the cracks on one face are horizontal. When the crack is on an end section, the heater should be lined up horizontally and a vertical weld made.

Preheating may be started most advantageously by spreading a bushel of previously ignited charcoal under the casting. Another bushel of charcoal is then distributed evenly between the furnace wall and the casting and ignited in four or five places by means of the welding blowpipe. When the fire is burning evenly the asbestos paper cover is placed over the furnace and several holes punched in it for draft and to allow escape of furnace gases.

After about 1½ hours a further addition of two bushels of charcoal should be made, taking care not to expose the casting to chilling drafts. In from 4 to 6 hours of slow heating the casting will have attained a uniform dull red color or about 1000 deg. Fahr., and is then ready for welding.

(E) *Welding Technique*

Only that portion of the casting adjacent to the crack should be uncovered in making the weld, in order not to cool the remainder of the heater section. If it is a horizontal weld the flame should be applied to the inside end of the crack and welding should progress outward to the edge of the casting. The edges of the crack

should be veed with the rod for about 2 in. and this section then welded. The operation is completed in a series of short welds, one after another, flux being added whenever sand, oxide and other impurities appear.

In making a vertical weld the flame should be directed at the lower end of the crack, and welding should progress upward. As little base metal as possible should be dug out with the rod, because the ease of making a vertical weld depends upon a narrow kerf. Care must be exercised in manipulating the flame and rod not to get the metal so fluid as to be "runny." By careful flame manipulation the vee can be built up step by step, thus avoiding a large, uncontrollable puddle of metal. A carbon block will often aid as a base on which to build the original section of metal, or to hold the weld metal in place.

The weld completed, the furnace should be recovered and the casting reheated evenly for from 15 to 20 minutes, adding more charcoal if necessary.

The asbestos covering and one wall of the furnace are then removed, and the casting turned to the next welding position. If a crane is available, it can be hooked to a chain previously passed through the upper connection holes.

If crane facilities are not available the casting may be turned in the following manner:

Two pieces of 1½-in. pipe 6½ ft. long should be inserted in the two lower connection holes. The heater section can be raised to a vertical position by one man bearing down on each pipe. One pipe is then removed and inserted in the upper middle connection hole, and the casting moved to the other end of the furnace. It can be lowered by placing the pipes in the lower connection holes again on the side of the casting opposite to that employed in raising it. It should be reblocked on fire bricks and steel wedges (or fire brick biscuits), and the furnace rebuilt.

The casting should be reheated again for about a half hour and the cracks on this side of the heater section should then be welded. Where a horizontal weld runs into a vertical weld, the latter should be reheated to a dull red for about 2 in. before the blowpipe is removed.

After all the welds are completed about one-half bushel of fresh charcoal should be added, the furnace covered, all draft holes plugged, and the heater section allowed to cool slowly in the dying fire for at least 24 hours.

(F) *Inspection and Test*

When the casting is stone cold it should be removed from the furnace, cleaned with a wire brush and examined for evident cracks. Before being passed by the welding foreman it should be required to stand the following hydrostatic hammer test:

It should be set in a vertical position and plugs inserted in the openings. These plugs were described under "Selection and In-

spection of Material." The rubber and steel discs are placed over diametrically opposite connection holes and drawn water-tight by C-clamps. A hydrostatic pressure of not less than 40 lb. and preferably 60 lb. should then be applied, as previously stated. While this is being done the casting should be hammered near the welds with a machinist's hammer. If no leaks develop, the casting is ready for service again.

Welding as a Means of Fabricating Tanks, Vessels and Pipes*

W. SCHENSTROM†

The riveted oil storage tank is the present standard and the details of construction are well known. In fabricating materials for the riveted tank, it is generally necessary to make templates, mark, punch and ream the plates. It is important that the edges of the plates are faired and that the size of the sheets is accurate. When erecting the tank it is necessary, in many instances, to drift as the plates must be drawn up tight, metal to metal, for riveting. Neglect in any one of these things will produce an inferior article.

In order to make the riveted construction possible, it is necessary to have angles, gusset plates, etc. The single, double and triple riveted joints increase the number of holes and caulked seams, and increase the possibilities for leaks.

The bottom and first course of a riveted tank are constructed on horses and after test, this portion of the tank is lowered down into final position on the foundation. The strains in lowering this portion of the tank may cause leaks which cannot be discovered. Again, leaks start when caulking edges have been strained unduly or often. Wind pressure, filling and emptying of the tanks and corrosion are some of the other causes of leaks.

The loss through leaks, seepage and evaporation from riveted tanks has not yet been closely estimated, but it is certain that the amount of the loss is tremendous, especially for the lighter grades of oil.

The oil storage tank of the present standard and construction, while satisfactory for want of something better, has certain limitations, which makes an improved design and construction method desirable.

Electrically Welded Construction

The electric arc welding method has for a long time been considered as the logical one to produce a more satisfactory construction than is possible with the riveting method and recently considerable construction work of welded oil refinery equipment,

---

*Presented at joint meeting of New York Section of A.S.M.E. and A.W.S., January, 1926.

†Welding engineer, Electric Welding Co. of America.

including various sizes of oil storage tanks, has been successfully completed.

In designing a large welded oil tank for the present time it is proper to follow the fundamental outline, such as the lapping of plates, as in riveted construction. New methods of welded construction of tanks are now being developed which will involve radical changes and which seem to offer great possibilities. The only present variations are details and simplifications which are special to the adoption of the welded construction. These details include the elimination of rivet holes, butt straps, gusset plates, angles, fairing of plates and a reduction in the laps of the plates. The plates do not have to be fabricated excepting in so far as the rolling is concerned.

Further, inasmuch as the welded lap joints are of 100 per cent or more strength, the plates in the shell can be lightened 15 per cent. The result should still be a structure 10 per cent stronger than the present standard of riveted tanks.

The thickness of the bottom and top plates is determined by practice, and until it has been demonstrated over a period of years that the corrosion of welded bottoms and tops is less than that of riveted bottoms and tops, it is doubtful whether it will be permissible to reduce the thickness of the plate of this portion of the tanks.

Portability

By applying the oxyacetylene torch in such a manner as to destroy only the welding metal in the joints, it is possible to cut down welded tanks and erect them again in the same manner as is done with riveted tanks.

Engineering of Welded Tanks

The electrically welded roof construction is gas tight and as is known, the saving in insurance premiums on gas tight roofs is considerable.

It is reasonable to assume that the insurance premiums on welded tanks will be lower than those on riveted tanks on account of reduced fire risk.

In the refineries where tanks are painted white, the saving in the paint bill amounts to considerable.

On some tanks erected in the field the bottoms were laid down on the ground and lap welded. The bottom angle was set outside of the shell of the tank and welded heel and toe before the side sheet was put up. The side sheet was then put in and welded at the joint between the side sheet and bottom from the inside and side sheet welded to the top of the angle on the outside. In welding the shells standard practice has been followed.

Welding on Large Tanks

From the amount of work done up to date, it has been definitely

established that the same procedure can be followed in the construction of any size tanks.

Various Tanks

The same thing that applies to oil storage tanks applies to most tanks. Today most small tanks are built welded.

Tanks built of 3/16 in. tank steel, 38 ft. long, 7 ft. diameter, 75 lbs. pressure have worked for years giving perfect satisfaction. In building these tanks very little is needed in the way of jigs, except cradles with rollers. Lap welds throughout with a couple of inch lap have been more or less standard, but butt welds for longitudinal seams are increasingly being used especially since automatic welders have come into extensive use. The heads of cylindrical tanks are generally set into the shell and a fillet weld applied in the corner, formed between the shell and the head. This applies to flat, dished and also flanged heads.

Gasoline and oil fuel tanks are probably the greatest output of the welded tank shops. The welded container is coming more into vogue in all lines. Oil fuel tanks in buildings are now usually welded. Some located probably in the shape of an "L" or a "T" or a cross is to contain the oil fuel. The largest wall opening to the street is probably 4 ft. x 7 ft. Tanks are wanted for a capacity practically the same as the complete cellar. Riveted tanks would have to be gotten at from the outside to hold against during riveting which would reduce the effective space too much. The welder comes along and sets his plates right up against the walls as near as the Fire Department rules allow and welds the tanks together from the inside entirely, bottom, sides and top. The welded tank so built can give 100 per cent space, and 100 per cent joint.

Vacuum Tanks

A patented welded tank, which is really a glorified thermos bottle, has made its appearance recently and is being used by people like Barrett for preparations that are desired to be kept hot at a constant temperature for some time. Hot Tarvia for roads, and other preparations, are carried in these welded vacuum bottles which have an inner and an outer shell with a space between, and nonconductor spacing pieces. By the welded construction it is perfectly feasible to get in excess of 29 in. vacuum in these tanks.

Pipe

The lap welded wrought iron pipe is a well known article. Recently the completely electric arc welded pipe has made its appearance. The welded sewer, gas and water main is now in daily use. Way back in 1915 a number of experimental sections were made up and tested and showed up well. The city of Ottawa came near building the first arc welded water pipe line, 5 ft. diameter, 7/16 in. thick. A 15 ft. test section was made up at that time 5 ft. in diameter, in two courses, all seams butt welded.

Flat heads of somewhere around 1 in. thick with a number of longitudinal stays through were butted on to the shell and as the heads were larger than the shell welds were made outside of shell in corner between shell and heads. At 500 lb. the heads distorted, so circumferential seams leaked more than pumps could put in. This was beyond elastic limit of the plate. The mayor of Ottawa and his engineers approved welded pipe, but it was not in the cards that welded pipe was to be used that time.

In connection with the new subways in New York the arc welded pipe has been used extensively, and anyone walking across Columbus Circle, or up Central Park West and St. Nicholas Avenue up to 175th Street and further, can see samples of the art. Note the distance between points of suspension, which speaks well for the strength and stiffness of arc welded pipe. That particular welded pipe is ¼ in. in thickness and 20 in. to 36 in. in diameter. For larger diameters than that the material is heavier. This pipe is made up in 36 ft. lengths in the shop in three courses welded together by means of a patented split sleeve arrangement which gives great strength and rigidity. In the field the pipe is made continuously by means of similar sleeve joints welded on the job. The welded field joint is preferred to the Dresser or other types of joints on account of the greater strength, absolute tightness, permanency and less cost. The drawback is that there is no reclamation value to the sleeve joint. New types of joints are made possible through welding. One called the "Donaldson" joint is a simplification of the ordinary joints used, and is approximately as follows: it is a telescope joint with a welded band around inner pipe to retain packing. A loose angle iron ring rides on the small end and fits in between inner and outer section. Lugs on outer section draw up the angle iron ring compressing the packing between the angle and the inner and outer pipe, and retain it in position.

The manufacture of large diameter pipe by means of arc welding requires a set of jigs, mandrels and rigs for the assembly of the cylinders for butt joints, sleeve joints and telescoping.

Lap welded 24 ft. long, sections in two courses of 48 in. diameter are first assembled in a cradle with expanders to get the inner section up, and with bands around outside to get outer section in. Then rolled over into parallel shafts, spaced suitably to receive the pipe sections lengthwise. The shafts are turned by a motor drive at suitable pace for welders to make circumferential joints without moving at all. The pipe is turned at the speed of the welding.

For butt welded pipe, automatic welding machines are used, using up to 800 amperes in the arc.

The cylinders are placed in a carriage on a roller bed and moved along the bed by means of a motor drive moving the carriage. Pipe cylinders are continuously fed under the welding head. The operator simply starts his arc when the end of cylinder gets under

his electrode and keeps the welding machine going until cylinder is welded. Great speed, accuracy, uniformity and consequent strength and lack of pores are accomplished with such machines. The cost of operation is a fraction only of the cost of hand work.

A 24 ft. section of gas pipe of 20 in. diameter, ¼ in. thick in two courses all butt welded with sleeve joint in center, and 2¾ in. flat heads set in was recently tested for the edification of gas company engineers to 950 lbs. when one of the heads gave trouble. Another test of a similar section of gas pipe, same dimensions, was tested for another purpose and showed 1150 lbs. pressure when the plate at one end of the shell ruptured where the straight head bulging had caused a flanging effect at the end of the shell. In no instance has an automatic weld shown less than 100 per cent strength in these tests.

The Pacific Coast has just recently awarded a contract for about 16 to 18 million dollars for 90 miles of electric arc welded water pipe. This is probably the largest arc welded pipe job ever undertaken. The advantages of this design are such that they cannot be ignored.

Just a word about inspection. The surface of an arc weld and especially the line of juncture of welding metal and original metal tell as much to the experienced eye as the visible part of a rivet. A trans-Atlantic liner just came into drydock in New York on account of the rudder having come loose in the gale of last week. On inspection it was found that the rivets holding the rudder to the rudder arms were slack in the holes up to ⅜ in. These rivets, some of them 7 in. long, had shanks that looked like corkscrews. Here was a case where the lives of thousands of people depended on the ship being built to navigate in the tremendous seas, and had the rudder carried away, there might have been a calamity. This case, as many cases on record where riveted constructions give way due to faulty materials or workmanship, don't excite any agitation for the discontinuing of riveted joints but simply are taken as individual instances where necessary evil and the human factor failed.

Because welding is new, such an experience with a welded joint would be taken as an indication that welding in general was unreliable. It is of importance that this new tool at the service of the engineering world be given a fair chance along with the riveted joints. The present day arc welding machine for hand welding controls the heat and energy input so that there is less opportunity for the operator to influence the quality of the welding one way or another than is in the power of the riveter to make or mar the riveted joint. The important point in the application of electric welding to all kinds of construction is engineering. Engineering should be given its proper place. There should be welding engineering taught in the technical schools and a whole new branch of engineering should be developed dealing with the problems of that particular line.

Gold in the Welding Processes*

By R. E. KINKEAD†

There is an old fellow up in southern Michigan I have known for a good many years who has a hide as thick as human hides ever get, but he also has a heart as big as a watermelon. Now the old man loves to murder fresh young salesmen. And at the time of which I speak we had one who held all records in that direction. I got the story in a roundabout way of what happened when our young spellbinder went up against the old man, but I think I can tell it substantially straight, although of course it will not be literally accurate.

The lad went at him something like this:

"Sir, I represent the most famous aggregation of welding experts in the United States and that means the world. We, as engineers, have spent more thought and study on the subject of welding than all of the other people in the industry. And I come to you, sir, with all of this knowledge to put it at your service to increase your profit, to expand your business, to make you the most successful manufacturer in your line of business in the country."

The old man looked out of the window awhile and dug around through the papers on his desk awhile until he found a half of a cigar, which he had started to smoke right after lunch, and relighted it.

"Yes, I have heard of your firm," the old man said. "Are you a technical man yourself?"

"Mechanical engineer from M. I. T. and two years' practical experience in welding application work. I think I know something about mechanical problems."

But if he had been older he would have seen the wicked gleam in the old man's eye and got his hat and gone away from there. But he didn't, so the old man let him have it with his time-honored gag:

"Well, son," he said, "with all your training and experience you certainly ought to show an old duffer like me something. Now I just want to ask you some questions.

"I have a paper weight here and I am going to roll it along this table, which is seven feet long. It will take the paper weight one second to go the length of the table. What is the true velocity of the paper weight?"

Right off the bat came the answer: "Seven feet per second."

"Now, son, I am disappointed in that answer," said the old man, "because I asked you for the true velocity and you gave me the apparent velocity. You know the paper weight was doing about a thousand miles per hour due to the earth's rotation before I started to throw it across the table. Besides that the paper weight had velocity due to the earth's travel in its orbit and due to the

*Presented at January, 1926 meeting, Western New York Section, A. W. S.
†Regional Director of Sales, Lincoln Electric Co.

drift of the solar system. I am afraid you never will know what the true velocity of the paper weight was, my boy.

"I want to ask you, young man, can you weld aluminum? We use a lot of it around here."

"Well, we do fairly well with the electric arc process on sheet aluminum," answered the lad, who by this time was getting a bit conservative. Then the old man sprung another old standby.

"Did you ever really see any aluminum?"

The lad fell hard. "Certainly, sir; the paper weight you have in your hand is aluminum and I can certainly see it."

"Son, you are getting more disappointing to me every minute," said the old man. "If you ever welded any aluminum you ought to know that oxide forms pretty rapidly on aluminum. In fact the only way you can weld it is to make your fusion under the surface of the molten metal, where there is no oxygen present. Now, you never saw any aluminum in your life outside of a laboratory. All you ever saw was aluminum oxide on the surface of aluminum, because aluminum as such cannot exist in the atmosphere."

The boy had enough by this time, and he went away from there. The old man was happy the rest of the day.

There is a real lesson for all of us in the old man's joke on the fresh young salesman. The old man did not know anything more than the average high school boy knows about velocity or the average high school boy knows about aluminum, but—get this point—he did know the relation between simple facts and could see them in their true perspective. Difference in mental ability is not so much a difference of actual knowledge as it is a difference in conception of almost universally known facts. After all, that is about all there is to welding.

Almost all of the important things in connection with the great field of usefulness of welding are universally known. The marvels which have come about in the industrial world by the application of welding have been accomplished by quite ordinary men by the application of quite ordinary mental processes.

Within a hundred miles of Buffalo, there is a plant which has been running night and day for the last three years trying to keep up with orders. This plant used to make large cast iron fittings used for oil, water and gas pipe lines. A workman in the plant got to thinking about the matter and decided that the fittings were too heavy and cost too much. The result was that they brought out a line of welded steel fittings which weighed half as much as the cast iron fittings and cost less than half as much to make. The users in the field saved a lot of money because less labor was required to move the lighter fittings around. While the cast iron fittings frequently leaked, due to sand spots in the castings, the welded steel fittings never leaked in service.

Now, isn't that simple? That workman did not know anything about integral calculus or a lot of other popular intellectual sports,

but he did know the relation between some very simple well-known facts.

Over in eastern Ohio, several years ago, a draughtsman and a couple of salesmen were talking one day and the subject was brought up relative to the difficulty of putting pipes, wires and ducts in a modern building due to the fact that the joists were solid. The result of that line of thought was a new joist woven from round bar stock and welded together. Every structural engineer in that little locality thought those fellows were crazy to make a joist in that way. Today those fellows are running one of the most rapidly expanding business institutions in the State of Ohio. Now, those fellows did not know anything about permutations and combinations in mathematics and there was a lot they had to learn about structural steel. They just looked into a situation and found out a better way of doing a job. They did not know a volt from an ampere or a welding torch from a cutting torch, but they did know how to do a job better than it had ever been done before.

After all about all there is to getting along in any business is to find out what people want to accomplish and then help them to do it better than it has ever been done before.

In 1914, I got acquainted with a boilermaker in a well-known shop. He was interested in welding, too. He made some kind of a deal with his boss so that he could stay in the shop after working hours and weld samples of different kinds of jobs. Shortly after that, he got another job as superintendent of a shop that did more welding. After a year and a half of that he went into business for himself, making welding repairs to machinery and boilers. Today that man operates the largest commercial welding shop to my knowledge in this country and is worth at least $250,000. This man knew two important facts and he made a fortune because he really knew the relation of those facts to other facts. This is the basis of his success:

1. Any factory manager would rather repair a broken piece of machinery than buy a new one, if he could be certain that the repair job would be satisfactory.
2. A considerable number of factory managers will sell good machinery which is slightly worn or broken for scrap value, because they cannot be convinced that satisfactory repairs can be made.

Now, my friend got them going and coming. Every plant in his district was a prospective customer. As soon as he found out that a plant had a broken or badly worn piece of machinery, he would go out and submit a bid to repair the machine. If the factory manager could not be convinced that the job could be done, my friend would try to buy the machine. If he bought the machine because the factory manager thought it could not be repaired, he of course bought it at scrap value. He would then repair the machine and

sell it to some other fellow and guarantee that the machine would not fail again where it had been welded or repaired.

I have told several stories here this evening, and if I have succeeded at all in what I am trying to do, I have made the point that opportunities for making money out of welding are pretty common. There are bigger opportunities right here in Buffalo than any I have mentioned.

The door of opportunity is open as never before to any man who knows what the torch, the electric arc or the resistance welder will do and knows the simplest things that are going on in Buffalo today. The machinery building and metal working industries of this industrial district will be revolutionized within the next ten years. The welding industry will be called upon to furnish more experienced individuals than it can possibly furnish. There are many operators of the welding processes today who ten years from today will be factory managers. There are plenty of men in Buffalo in the welding industry today who are making two thousand dollars a year, who will be making ten thousand dollars a year in ten years. You say, how do I know all these things? That is reasonable. I have seen these things happen, all of them, in the last ten years, and they are happening with increasing frequency—tremendously increasing frequency. Now, that reminds me of a little incident which happened last week right here in Buffalo.

I was in one of the largest shops in the city and was casually talking to one of the welding operators, who was lamenting the bygone happy days when a good welder could get a dollar and a quarter an hour, and have the Boss call him "Mister" every time he passed through the shop. The welding operator turned back to his work, and I stood in the same spot and made a survey of the welding opportunities I could see without stepping out of a one-foot circle.

The first thing I saw was a charging machine for handling material to and from a couple of large annealing furnaces. The machine was evidently built specially for the purpose of that particular plant. A rough calculation of the cost would indicate that not less than $7,500 in capital was tied up in that charging machine. Then I looked for welding applications on the machine. Here is what I saw. That charging machine could have been built complete for $1,500 by the very man who thought the happy days of welding are over. The fellow who designed that charging machine spent more for patterns alone than the whole machine should have cost.

The next thing I saw was a battery of large presses, worth not less than $150,000. Now presses are designed and sold a good deal like gas engines, air compressors and similar machinery. They sell by the pound. The heavier you can make them, the more money you can get for them. Of course, that being the case, the best material to use is cast iron, because this material gives less strength per pound for the purpose than any other material of construction used for the purpose. Now, these presses were supplied

with cast iron frames that were heavy enough to sink a battleship. Our discontented welder friend could have welded together some structural steel and made those press frames and saved his firm $50,000 on these presses.

Over in the corner were two storage battery trucks made right here in Buffalo. They had steel frames riveted together and were loaded down with castings which could have been made of welded steel at a saving. The sorry welder could do a lot of things for the fellow who makes that shop truck.

Now, the interesting thing about this situation is that the fellow who could not see the opportunity for welding actually knew as much about the fundamental facts as anyone and probably a lot more than most people who know nothing of welding.

We are very apt to think that while welding will not do anything for us, if we could only get over into the other fellow's plant we could show him a thing or two that would open his eyes. But the big opportunity is right at home with the things we know most about. You have, of course, heard about the people who couldn't make any money out of their big cast iron lawn rollers, because they cost more than any householder was willing to pay to have a nice lawn. They had to be heavy, which meant high cost and large freight charges. One day a welder asked them why they did not weld up a steel can and leave a bung in it so that the purchaser could fill the can with water when he got it to make it heavy. Well, they could sell lawn rollers after that, and they are selling them today.

I do not want to convey to you the idea that the possession of knowledge, training and experience is a handicap to your success in the welding industry. I do want to convey the idea, however, that the biggest successes have been made by the intelligent application of almost universally known facts. It has been my privilege to do some work with one of the most distinguished automotive engineers in this country. The great achievements of this man have been due largely to his ability to see well-known facts in their true relation to each other. The gentleman I refer to is Mr. Charles F. Kettering, president of the General Motors Research Corporation. Perhaps you have heard of the job which he did in connection with the painting of automobile bodies. It was a marvelous achievement. It has effected savings which already have run into millions of dollars. Let me illustrate by this job the simplicity and directness with which this great man's mind works.

The automotive industry had reached the point in the number of cars produced at which the capital tied up in buildings to house the automobiles in process of manufacture had become a serious burden. He undertook the job of improving the situation. He found out that it took eight to ten days to paint the body. Now it was evident that a company making a thousand cars a day would have to have building space to cover eight thousand cars if it took eight days to paint one car. If the time could be shortened to four

days, it would only take building capacity for four thousand cars. The difference in capital outlay for buildings in the automotive industry runs into millions of dollars, not three or four million dollars but in terms of fifty million dollars. This distinguished engineer went to the foreman of a paint shop and started to ask questions, and I will try to give you the substance of the conversation. Please keep in mind that this engineer is distinguished in the field of chemistry, electrical engineering and a lot of other technical subjects. He said to the foreman:

"Why does it take you eight to ten days to paint a car?"

The foreman said, "Because it takes a long time for each coat to dry."

The engineer asked "Why?"

After some shifting around the foreman answered that they used a linseed oil base for the paint, and that they didn't know how to dry the linseed oil paint any faster.

The next question the engineer asked was, "Why do you use linseed oil?"

To which the foreman replied that he didn't know; that linseed oil had been used for paint ever since he had been a painter and that he did not believe that you could use anything else.

Well, Mr. Kettering and his engineers simply went out and found a paint that didn't take so long to dry. The first paint they tried using a spray gun dried so fast that between the time it left the gun and the time it hit the body it had dried so much that it wouldn't stick to the body. From then on the problem was merely one of slowing down the speed with which that paint dried, so that they could keep it wet long enough to get it on the body.

Duco paint for automobiles is the result of this research, for that is what it was; and it has saved the automotive industry millions of dollars, and it is a better paint than was ever used for the purpose before. Now isn't that simple? Here is one of the biggest engineering jobs that has been done in the automotive industry in the last ten years. It was done by a man of distinguished technical achievement, yet it was so simple that anyone of us might have done the same thing without the technical equipment available to Mr. Kettering.

Great progress is open to you and me if we can only see the relationship between the simple facts with which we are already familiar and with which we come in contact every day.

I have talked to a good many fellows in the welding industry who have told me that if they had a lot of money they could do some wonderful things in the welding industry. But the strange part about it is that most of the big things that are done in this world are done by some fellow who hasn't got much money. That is the reason he does them.

Let me cite a case with which I am familiar. A number of years ago, I was down in New England and I heard of a little welding shop that wanted an arc welder. I called on the man and had a

talk with him. His little "hole in the wall" shop was filled up with fifty cent welding jobs, such as broken furnace shakers, stove lids and other jobs which every welding shop would rather do without. After talking with the proprietor for awhile, he told me that he would like to have one of our welders, but that he did not have any money to buy it with. We were not at that time running a philanthropic institution, so that my conversation from that point on had mainly to do with the weather and with other subjects entirely foreign to the welding business. I was going to Boston and asked the fellow what time I could get a train. He said that there was one in fifteen minutes and that since he had to go to Boston, too, we might ride together. On the way into Boston he got to telling me how he happened to be in the welding business. He had been a college professor. As his family grew in size it became evident to him that his college professor's salary was not going to provide for that family. He became interested in welding and thought that he could make a success of it. He talked the matter over with his wife and told her that so long as they were going to starve, anyhow, he would like to take a chance at the welding business and see if he could not do a little better. His wife said to go ahead, and that she would stand by him no matter what happened.

Well, the first thing he did was to rent a little ramshackle house just out of town, with four acres of ground around it. The next thing he did was to plant four acres of potatoes. He figured if the welding business didn't go they would still have potatoes to eat. He had been in the welding business about a year when I saw him, and he said that he believed he had turned the corner. People were beginning to find out that he could do something for them. He had broken even from the start, and now was beginning to make a little money, which he was putting back into the business.

When we got off the train at the South Station in Boston, I said to him, "Mister, I am telegraphing our people to ship you the welder you want. You put it into service and if at any time you have any spare change send it on to Cleveland and we will credit it to your account. That equipment was paid for in full within three months. Today that man is financially independent and is one of the best known commercial welding men in the New England States.

Now, it didn't take money for that man to make a success. It didn't take high-power technical ability. As a matter of fact, he taught history and English literature. He knew how to do something better and cheaper than it had ever been done before in his locality and he made himself financially independent because he had the courage and will to serve his neighbors.

In closing, I am going to tell you how to find the gold in the welding processes. Find a way to do a job better and cheaper than it has ever been done before. Pick the job with which you are most familiar and you will find that the best way of doing it is perfectly obvious and so simple that you will wonder why no one ever thought of it before.

Fusion Welded Pressure Vessels*

S. W. MILLER†

While engineering has been defined in many ways, the fundamental idea involved in the use of the term is that it is concerned with the employing and developing of the materials and forces of nature for the use of mankind, an engineer being one who is occupied with this work.

There is not and cannot be, a sharp line of division between any two of the many fields of engineering, but in a general way mechanical engineers are concerned with machinery, boilers, engines and their appurtenances, among the latter being piping and containers of various kinds.

The applications of fusion welding to these structures have been great both in number and size, and many of them have been in successful operation for a long enough time to make it almost certain that no trouble will arise in the future in any of these cases, and to warrant an increase in number, size, and kind of applications of the processes.

An engineer controls the materials and structures he works with, by means of specifications. He draws up these specifications from his own experience and that of others, including the results of well planned and executed tests, so that by using good judgment he is able to obtain the results he desires. It may well be that in some cases he does not have all the information he needs, but that does not deter him, as he always finds ways to get what he wants.

Further, if any design, construction, or process is advantageous, it is the duty of the engineer to learn about it and use it when and where he can. This may require some study, but one of the engineer's most precious privileges is to investigate and learn.

Now with regard to fusion welding in general, it seems to me very clear that the advantages of the processes make it incumbent on the engineer to study them thoroughly, so that he may use them intelligently, and that he is not fair to himself unless he does so.

It is admitted by all those to whom I have talked that good welding can be and is being done. To deny this would be to deny facts. If it is being done, someone must know how to do it, and so he would be rash indeed who would say that engineers could not draw up specifications that would insure good welding.

A code differs from a specification in that it governs all specifications, and in that it is written primarily as a safety measure. In other words, the author's conception of a code is that it is a description of the minimum allowable requirements for safety. But a code must not contain requirements that are prohibitive or even unduly restrictive to the industry, if it is a fact that by the use

*Presented at joint meeting, Metropolitan Section, A. S. M. E. and New York Section, A. W. S., January, 1926.

†Consulting engineer, Union Carbide & Carbon Research Laboratories.

of good material, design and workmanship, a product can be safely made that is safe. Therefore, in the author's view, there is no room nor place in a code for any restrictions based on any assumption that bad workmanship may sometimes be used.

It should be pointed out that the responsibilities of the code committee, the inforcing body, and the engineer, are essentially different. They correspond rather closely to those of the legislative, administrative, and judicial departments of our government. The code committee is the legislative, the inforcing body is the administrative, and the engineer is the judicial, factor.

The code committee makes the code, and should produce one that is fair to the producer, the consumer, and the public.

It is theoretically very simple to make a code, but there are many practical difficulties in the way. These are quantitative rather than qualitative, and are usually due to a lack of definite knowledge. Mere opinions are not data, and as a code should be based on sound engineering data, such opinions are of little or no force or value. So the committee should insist on definite evidence, getting it where and how they can.

The author knows of no other code than the A.S.M.E. unfired pressure vessel code that contains restrictions based on the assumption of poor workmanship. While it is not denied by any one that there have been some cases of failure of welded pressure vessels due to this cause, there are thousands of welded pressure vessels that have not failed, and it is a fact that good welding does not fail.

It is bad logic to condemn fusion welding as a dangerous *process*, because of these failures, unless it be admitted that failures of other types of joints due to the same cause also condemn the *processes* by which they are made. Such reasoning is obviously more harmful to the one using it than it is to the welding industry.

After the code has been made, it must be inforced if it is to be of any value, and this is the duty of the State, through its authorized representatives. It cannot be done by the code committee. Therefore, as local conditions and laws differ, each inforcing body has problems that it must solve in accordance with its own peculiar difficulties.

Further, as the State must do the inforcing, the code should not contain any references to inspection, stamping, or other matters that relate to the duties of the State. Also no attempt should be made to specify methods of doing work, tests for operators, or other similar matters. These are functions primarily of the manufacturer, and secondarily of the inspector employed by the engineer or the constituted authority.

Also, as it is the duty of the State to inforce the code, the State should do so, and not avoid its duty by trying to prohibit or unduly restrict an industry. It is probably true that there are not at the present time enough competent welding inspectors in State employ to inforce thoroughly a good code, but that is not the fault of the

code, and certainly a committee should not allow itself to insert restrictions in a code for any such reason as this. Obviously if a good code were completely inforced, there could be no accidents.

The unfired pressure vessel code of the A.S.M.E., in my judgment, needs revision of the parts relating to fusion welding, if it is to command the respect it should from those familiar with welding practices and possibilities. Probably the easiest way to revise would be to rewrite, and so the author ventures to present a code for fusion welded vessels, believing that, while it is doubtless not perfect, it is much more accurate and workable than the one he criticizes. It is only fair to say that changes in the most important items have been presented by the American Welding Society to the Boiler Code committee for their consideration, and that it is expected that some modifications in the present restrictions will be made, because of the engineering evidence that accompanied the presentation, and because of the advances recently made in welding.

But it is the belief of the author that the recommendations referred to are not as liberal as would be perfectly safe, and so he has gone still further with the idea of using the latest practices and methods as a basis for the proposed code.

Experience and observation warrant the statement that at present it is no more difficult to train men to make perfectly satisfactory welds, than it is to train them to make any otner satisfactory product. Some may find it hard to realize this, but it is true, and it has been proven so many times in the last two or three years, that to deny it would be simply to deny the facts. The welding of 140 miles of 8-in. pipe by 44 welders who made 18,000 welds in which the only defects were four pinhole leaks, which were calked, is one instance. This pipe is an oil line operating under a maximum pressure of 750 lb. per sq. in., and during a severe storm was in places washed out of the trench 20 feet from its position. It was pulled back into place without stopping the flow of oil and without any leaking.

Another case is three tanks, 7 ft. diameter, 35 ft. long, of ¾-in. material in the shell with heads 1 in. and 1⅛ in. thick, for 125 lb. working pressure, the hydrostatic hammer test at 375 lb. being used, under which the tanks were all perfectly tight. These were the first large welded tanks made by the manufacturer, and the author believes the largest fusion welded pressure vessels ever made.

Still another instance is the welding of a line kiln shell 125 ft. long, 8 ft. diameter of ⅝-in. material. It weighed 15 tons less than a riveted one of the same shell thickness and its alignment was well within the specification limit. It is interesting to know that the apparent fiber stress across the riveted joints was twice the stress across the corresponding welded joints, due to unavoidable movement in the riveted one. Over two years service has failed to develop any defects in the welds. Such instances might

be multiplied, but as each one was a pioneer job, they prove the contention that good welding, even in unusual jobs, is easily obtained, provided the will to obtain it exists.

There is also submitted a specification for a definite tank, of the maximum diameter that can be made for 200 lb. working pressure with a ¾-in. thick shell, though, as noted above, larger diameter tanks, but carrying less pressure, have been successfully made. Of course, different conditions would alter the specifications, and the one given is only a guide to the engineer. It will be noticed that the requirements are more rigid in some respects than the proposed code calls for, because they embody the author's opinion of the best possible design and construction, such as might be desired in a special case.

There is also a list of published articles that may be of interest to the engineer, as well as to others.

Proposed Code for Fusion Welded Pressure Vessels

All provisions in the A.S.M.E. pressure vessel code shall apply to the vessels covered by this code, unless such provisions conflict with those in this code, in which cases this code shall apply.

1. The term fusion welding in these rules shall be considered as applying to the oxyacetylene and metallic arc welding processes,

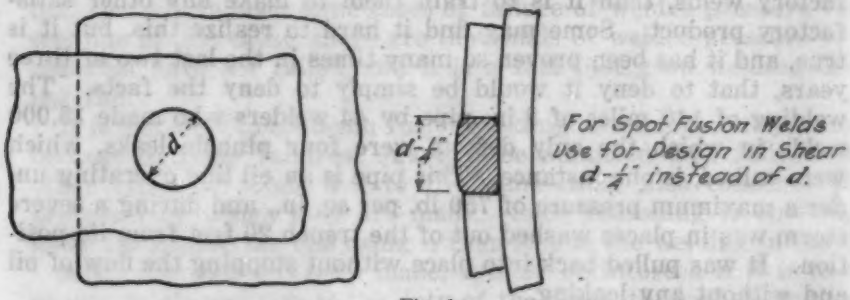


Fig. 1

the work being done by hand, and ordinary welding materials of good quality being used.

2. Longitudinal seams shall be of the double-V type, that is, welded from each side half-way through the sheet. Girth and head seams may be of the single-V type, that is, welded entirely through from the outside. Double-V longitudinal welds shall be reinforced at the center of the weld on each side of the plate by at least 25 per cent of the plate thickness. Double-V girth welds shall be reinforced at the center of the weld on each side of the plate at least 10 per cent of the plate thickness. Single-V welds shall extend entirely through the plate and shall be reinforced at the center of the weld by not over 20 per cent of the plate thickness. All welds shall be of sound metal, thoroughly fused to the sides of the V for its entire depth. Sheets must not be allowed to

lap during welding. In material ¼ in. or less in thickness, the longitudinal seams need not be beveled. In material less than ¼-in. thick, beveling the heads will be sufficient, and the shell need not be beveled at the head seams but one side of each girth seam shall be beveled.

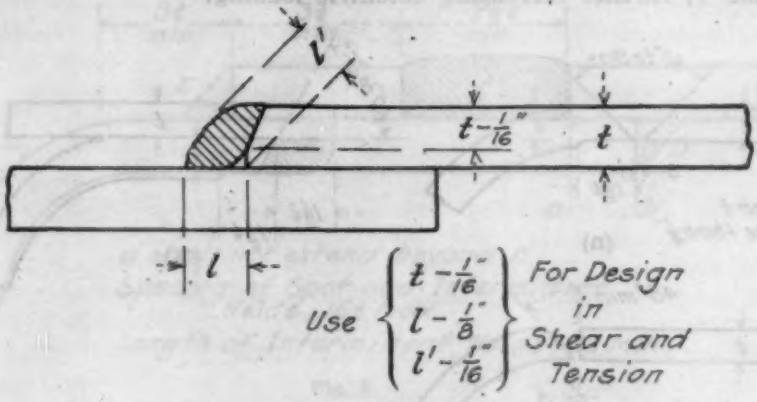


Fig. 2

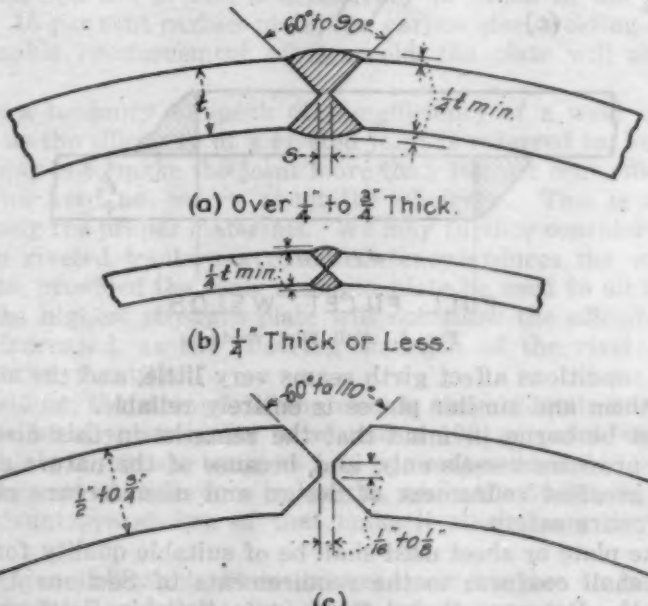


Fig. 3. Gives design dimensions and is not to be used in construction

There shall be no valley either at the edge or in the center of the joint, and the weld shall be so built up that the welded metal will present a gradual increase in thickness from the surface of the sheet to the center of the weld.

At no point shall the sheet on one side of the joint be offset with the sheet on the other side of the joint in excess of one-quarter of the minimum thickness of the plates.

Note—There is little if any additional cost involved in the making of a double V seam over that of a single V. The former is also symmetrical and so causes no eccentric loading. Further when ordinary welding rod is used, and the code is based on its use, there is a strong tendency for defects to occur at the bottom of the V, further increasing eccentric loading.

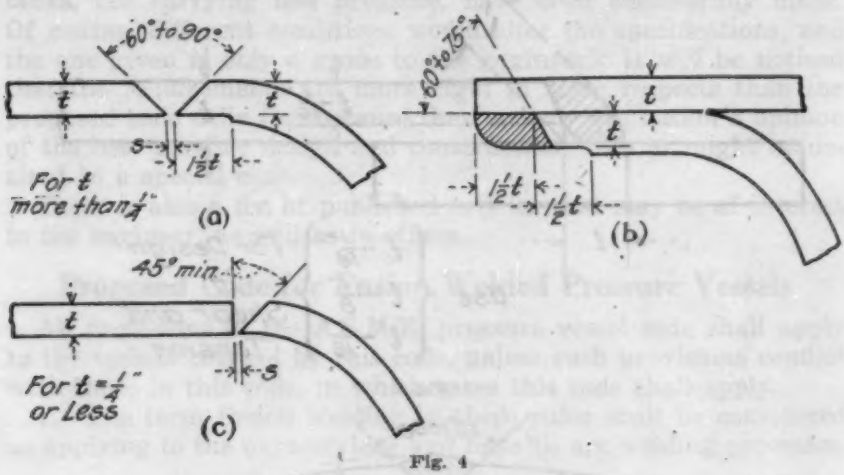
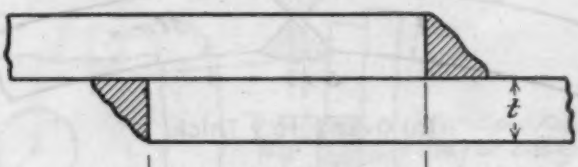


Fig. 4



FULL FILLET WELDS

Fig. 5. Full fillet welds

These conditions affect girth seams very little, and the single V weld in them and similar places is entirely reliable.

It must be borne in mind that the remarks in this discussion apply to pressure vessels only, and, because of the nature of their use, the greatest refinement of design and manufacture must be used to insure safety.

3. The plate or sheet used shall be of suitable quality for welding and shall conform to the requirements of Sections U110 to U125 of the Pressure Vessel Code, or to those in Sections S5 to S17 of the Power Boiler Code, except that the carbon content shall not exceed .18 per cent and that the limits of ultimate tensile strength shall be from 48,000 to 58,000 lb. per sq. in.

Note.—The materials specified for sheets and plates in Section U71 are, in my judgment, satisfactory, except that I would limit the carbon content to a maximum of .18 per cent in the cases of flange and firebox steels. The reasons are,

1st—The lower the carbon in the steel, the less is it injured by heat and mechanical work.

2nd—The lower the carbon the better the distribution of welding stresses.

3rd—The lower the carbon the higher is the relative strength

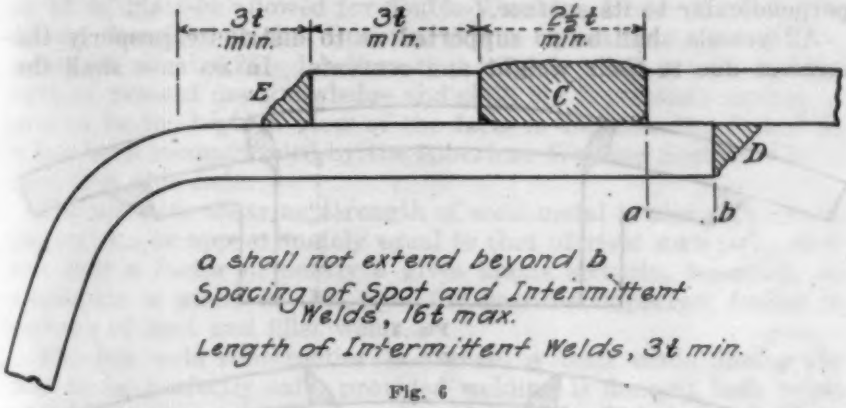


Fig. 6

of the weld, and the greater the tendency to break in the plate, until with .15 per cent carbon plate, low carbon steel welding wire, and reasonable reinforcement of the weld, the plate will always break.

There is a tendency to speak of the efficiency of a weld in the same way as the efficiency of a riveted joint is referred to, but the only safe way is to make the joint more than 100 per cent efficient, and then we need not worry about the efficiency. This is easily done by using the proper materials. We may further consider that, while with riveted joints a greater efficiency reduces the weight of the plate, provided the same strength plate be used in all cases, yet even the highest strength plate will not allow the efficiency to be much increased, as the shearing strength of the rivets is a rather definite quantity.

With welding, the strength of the weld is also a definite quantity in the case of any particular wire, and a 100 per cent weld in 50,000 lb. plate is just as strong as a 50 per cent weld in 100,000 lb. plate, so there is no difference in weight, while the 50,000 lb. plate has the advantages spoken of that make it much more desirable material.

4. Maximum allowable fiber stresses on welds due to internal pressure shall be as follows, per sq. in. of plate section.

In tension	
Butt double-V longitudinal welds	8,000 lb.
Butt single-V girth or head welds	6,500 lb.
Double full fillet girth or head welds	7,000 lb.
Spot or intermittent fillet head welds	5,600 lb.
In shear	7,000 lb.
In compression	15,000 lb.

Where spot welds are used, as in Figs. 1 and 6, the calculation for strength shall be based on the diameter of the hole minus ¼ in.

Where fillet welds are used, as in Figs. 4, 5, 6 and 7, the calculation for strength shall be based on the length of the weld minus ⅛ in., and on the thickness of the weld minus 1/16 in., measured perpendicular to its surface.

All vessels shall be so supported as to distribute properly the stresses due to their weight and contents. In no case shall the

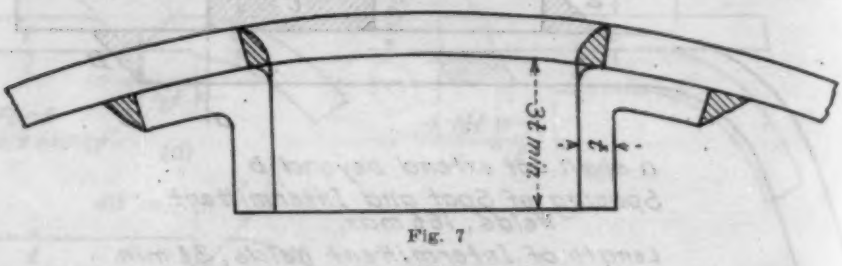


Fig. 7

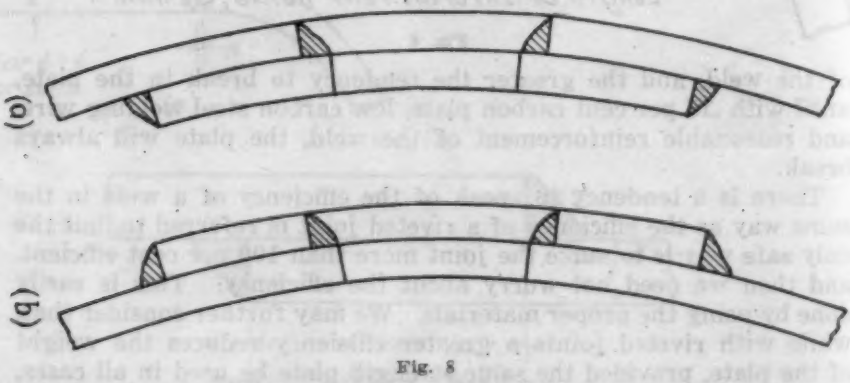


Fig. 8

working fiber stresses on welds be increased by any stresses other than those due to internal pressure more than 500 lb. per sq. in. of plate above those allowed for that pressure.

Note.—Section U68 allows a maximum tensile fiber stress of 5600 lb. per sq. in. for both double and single V welds.

This is taken from test results given in Prof. R. J. Roark's paper before the A.S.M.E. in May, 1922, in the table on page 26 of the preprint, and in the early drafts of the code appeared as 28,000 lb. with a factor of safety of 5. (See also Heating Boiler Code, section H70.) From the latter it is clear that the stress is per sq. in. of plate section.

The figure in Roark's table, however, is per sq. in. of weld section, and when reduced to plate section it becomes 7000. If it be fair to take it as a sound engineering datum, then 7000 should be used instead of 5600. But 35,000 lb. ultimate strength is too low for even a single-V weld made by a competent operator, as any one familiar with weld tests knows, and indicates clearly lack of penetration or fusion, which would readily be seen by even superficial

examination. There can be no objection to rating a single-V girth weld at 6500 lb., the proposed figure. Double-V welds are shown by Bulletin No. 5 of the A.W.S. to be much superior both in consistency and strength to those of the single-V type, and the A.W.S. recommended that a maximum tensile fiber stress of 8000 lb. per sq. in. of plate be allowed for double-V welds. Under the test conditions described in that Bulletin, this is equivalent to a factor of safety of about 6.25. I believe that 8000 is much too low in the light of present day knowledge and skill, but it certainly cannot be said to be too high in view of the facts in Bulletin No. 5, and as it has been recommended by the American Welding Society, I have used it in this code.

The ultimate shearing strength of weld metal is about 40,000 lb. per sq. in., or approximately equal to that of rivet material. It is felt that a factor of nearly 6 gives ample security, especially as allowance is made in this code for possible imperfect fusion in corners of spot and fillet welds.

The lap weld construction is known by tests made during the war to be perfectly safe, provided welding is done at both edges of the lap, or an equivalent spot weld is used. This latter is feasible with small diameter tanks.

The compressive strength of weld metal is seldom used in tanks. As the weld is usually low carbon steel, and as it is never the controlling factor in tank design, the figure given is safe, and is introduced for completeness.

5. Where vessels are made up of two or more courses with welded longitudinal joints, the joints of adjacent courses shall be not less than 60 degrees apart.

Note.—This is the same as Section U72.

5A. The provisions of sections U53, U54, and U62 of the A.S.M.E. code shall govern the application of manholes and handholes.

Manhole openings, if elliptical, shall be not less than 11 x 15, or 10 x 16 in., if circular, not less than 15 in. in diameter.

Handhole openings shall be reinforced as are manholes, when their greatest dimension is over 6 in.

Manhole frames shall be of wrought steel at least as thick as the plate to which they are welded, but not more than 25 per cent thicker, and if welded, shall be applied as in Figs. 7 and 8, the welds being full fillet, and extending all the way around inside and outside.

The total section of the frame at any plane passing through its center shall be at least equal to the section of the plate removed along the same plane.

The outside weld shall be so designed that its tensile and shearing strengths shall each be equal to the tensile strength of the material removed from the plate.

Note.—It has been found by stress strain measurements that

with the method of design given, there are no serious stresses around the manhole opening at the working pressure. The provisions are mostly copied from the A.S.M.E. code, with slight changes in the wording to suit welding conditions.

6. The shell shall be substantially circular at any section.

This is taken from Section U73, the instructions as to how to obtain the result being omitted as not belonging in a code.

7. Heads shall be dished and flanged, and shall be designed in accordance with Sections U36 to U39 of the A.S.M.E. code, except that when a manhole frame is welded in a head in accordance with this code, no increase in head thickness will be required.

(In this code a convex head means one convex to the pressure, and a concave head one concave to the pressure.)

They shall be attached to the shell as shown in Figs. U3-J or U3-K of the A.S.M.E. code, or Figs. 4, 5 or 6 of this code.

A head inserted in a shell shall be well fitted and a driving fit therein.

The minimum length of head flanges, either convex or concave, shall be as follows:

Inside Diam. of Tank	Min. Straight Length of Flange
12 in. and less	1¼ in.
over 12 in. to 24 in.	1¾ in.
over 24 in. to 36 in.	2¼ in.
over 36 in. to 48 in.	2¾ in.
over 48 in. to 60 in.	3¼ in.

In any case in which the head is over ¼-in. thick and more than 1¼ times the shell thickness, it shall be reduced to the shell thickness as shown in Figs. U3-J and U3-K. The use of a double-V girth weld will be considered the equivalent of Fig. U3-J.

The calculated strength of the construction in Fig. 6 shall be such that the strength of the outside fillet weld, and the sum of the spot or tack welds shall each be equal to at least 30,000 lb. per sq. in. of cross section of the shell.

Note.—The greatest objection to the usual design of welded concave inserted head is that it is not possible to prevent some bending stress on the weld, because of the distortion of the head under pressure, and because a perfect fit cannot be had between the head and the shell. The design using spot or tack welds at the end of the flange as shown in this code avoids this bending and so makes a safe construction, which should be allowed.

The calculated strength of each part of the weld is 37½ per cent of 8000 lb., a total of 75 per cent, rather more than the theoretical 50 per cent ratio of the strength of a girth section to a longitudinal one.

The design also provides for omission of the theoretical corner strength of a perfect weld, as it is sometimes difficult to get these corners thoroughly fused.

8. Nozzles in heads and shells shall not exceed 12 in. nominal diameter. They shall be of forged or rolled steel, and shall be welded to the shell or head as shown in Fig. U3-A. The nominal diameter of the nozzle shall not exceed one-third of the shell diameter.

Note.—This has been changed from Section U-76 to make the nominal size limit clear. The ratio of diameters of the shell and nozzle should not be less than 3 to 1, in my opinion, in a pressure vessel. In piping the fiber stress is much less, and a smaller ratio, even 1 to 1 is permissible in many cases.

9. Threaded connections shall not exceed 12 in. nominal diameter and shall be made as in Figs. U3-b to U3-i and Table A. Flanges shall be of forged steel and shall fit closely to the plate before welding. Pipe nipples shall be of extra heavy pipe for a distance from the shell of at least six times their nominal diameter.

Where nipples are threaded into the plate without any welding, and the plate is too thin for the number of threads called for in Table U5 of the A.S.M.E. code, a boss may be built up by fusion welding to provide for such threads, if the nominal pipe size does not exceed 2 in. The nominal diameter of threaded connections shall not exceed 1/3 the nominal shell diameter.

TABLE A

Flange, Nozzle and Pipe Connections

Figure	Shell Thickness	Allowable Working Pressure	Shell Diameter	Maximum Nominal Pipe Size
U3-A	any	any	any	12″
U3-B	any	any	any	12″
U3-C	any	any	any	3″
U3-D	any	any	any that can be welded inside	8″
U3-E	any	250	any that cannot be welded inside	4″
U3-F	any	150	any	2″
U3-G	any	any	any that can be welded inside	8″
U3-H	any	100	any	2″
U3-I	3/16″ min.	any	16″ min.	1″
I	1/4″ min.	any	30″ min.	1½″
I	3/8″ min.	any	48″ min.	2½″

Note.—Forged steel flanges have been required, and the building up of a boss is copied from Section U59, for completeness, with the 100-lb. pressure limit omitted, as I believe it to be entirely unnecessary.

Table A is copied from Bulletin No. 5. I believe it to be more rational than the limits in Fig. U3, because it takes account of practical conditions and welding possibilities, as well as giving more scope in the application of nipples in perfectly safe ways.

10. Each tank shall be tested under hydrostatic pressure to 1½ times its maximum allowable working pressure, care being taken to remove all air from the tank and its connections. While under this pressure, it shall be struck swinging blows at intervals

of 6 in. along all seams with a hammer of from 2 lb. weight for ⅛-in. shells to 12 lb. for ¾-in. shells, the hammer being allowed to fall freely from full arm length but with only the force of its own weight.

After this test the pressure shall be raised to three times the maximum working pressure and be held there 3 min.

Note.—The above test is that recommended by the A.W.S. in Bulletin No. 5, and is practically the same wording as U78, the changes being with the idea of making the test more easy of interpretation and execution.

It is impossible to discuss it fully here. Bulletin No. 5 devotes three pages in the Bureau of Standards report, and six pages in the committee report to it.

In general it was shown that even a permanent distortion of a tank by the hydrostatic test seems to have no detrimental effect on the strength of a properly welded tank, and that the hammer test does detect some defects that otherwise would be missed.

The results do not show that this test will invariably detect a tank that I think should be rejected, and even a test pressure of four times the working pressure would not accomplish this.

No one has yet defined a bad weld, and so it is not possible to agree on how far a test should go. But it is sure that a double-V weld is good, and as Bulletin No. 5 shows that it is in all cases thoroughly reliable, and as no double-V weld has ever failed, let us spend our time in making and improving what we know to be good, and then we need not worry about bad welds and how to find them, for there will be none.

Omission of Some Parts of the A. S. M. E. Code

It will be in order to explain why many of the A.S.M.E. code provisions are omitted in this proposed Code.

Section U17, giving the minimum allowable thickness of shell for given diameters, corresponds to similar provisions in other A.S.M.E. codes. (See section P17 of the Power Code, and Section H12 of the Heating Code.) In U17, I believe the thickness of the smaller diameters was designed to allow for some corrosion. This is a matter that does not belong in a code, as corrosion is different in different places, and is therefore a matter for local decision and inforcement. Section U11 provides a general increase in thickness for corrosive contents, and Section U53, U54 and U62, refer to means for internal inspection. If these provisions are followed there is no need for additional allowance in the thickness requirements, which should be based, as in other codes, on the allowable distortion due to the weight of the tank, or similar considerations, so that the inherent advantage of welded thin shells over riveted ones may be available.

It is hard for one not used to welding possibilities to visualize that a tank 16 in. in diameter and 10 gage in thickness required a

pressure of 990 lb. per sq. in. to burst it, but Bulletin No. 5 shows it to be a fact.

I have omitted any minimum limits for thickness and have depended on the provisions of Section U60, which says that supports must be such as to distribute properly the stresses due to the weight of the tank and its contents, adding that in no case should the stress on any part of the tank be increased more than 500 lb. per sq. in. of plate by the weight of tank and contents, or attachments to the tank over the maximum allowable fiber stresses due to pressure. This insures proper design of the supports. The third sentence of this section is not applicable to welded vessels, as it refers to riveted construction only.

Section U23 contains the following provisions for fusion welded vessels.

Longitudinal welded seams shall be used only for air vessels and then the diameter cannot be over 20 in., the length over three times the diameter, or the pressure over 100 lb. per sq. in. Circumferential welds are limited to tanks 48 in. diameter unless the heads are flat and 75 per cent of the load is supported by stays, when the diameter may be 72 in.

There is no sound engineering reason for any of these restrictions, and therefore they have been omitted. The tanks in Bulletin No. 5 were 24 in. in diameter, $\frac{3}{8}$ in. thick, and many of them stood 1600 lb. without leaking before rupture. This alone is sufficient to show that the code limitations are unreasonable. There is plenty more evidence to confirm this.

It is also evident that if it is safe to weld material $\frac{5}{8}$ in. thick, which is permitted by the code in Section U70, and if a fiber stress of 8000 lb. is safe, as shown by Bulletin No. 5, there is no need for any other restrictions, as these two automatically decide the diameter and pressure. I know that it is perfectly safe to weld material $\frac{3}{4}$-in. thick, and as tanks of this thickness have been made, tested in accordance with the code, and proven satisfactory in service, this thickness has been allowed. There is no reason why greater thicknesses cannot be welded. In fact, $1\frac{1}{2}$ in. and 2 in. plates have been successfully welded, breaking at over 60,000 lb. per sq. in. of plate or else, with lower strength plate, outside the weld.

Therefore, the 3/16 in. thickness limit imposed by the code for longitudinal seams, is uncalled for, and has been omitted.

There is no reason for limiting the diameter of welded vessels that would not apply equally to vessels with other types of joints. A weld is equally safe in 3/16-in. plate whether the diameter is 20 in. or 20 ft. If the volume of a large vessel is objectionable, either apply efficient and sufficient safety devices, or make the restrictions apply to all vessels. Other procedure than this is not based either on logic or engineering. The restriction applies only to fusion welded vessels, and so has been omitted.

The length of longitudinal seams is limited to three times the diameter. There is no good reason I know of for this, there being no relation between diameter and length that influences the strength unless the tank be very short, and as in Bulletin No. 5 the test results show that the bursting fiber stress was practically equal to the ultimate strength of the plate, and as these tanks were not over three times their diameter, it is clear that with this ratio any influence of the heads is absent just as much as it would be in longer tanks, so there is no point in limiting the total tank length, unless a much smaller ratio than 3 to 1 be adopted.

However, there is a practical reason for limiting the length of any course, which lies in the difficulty of welding the inside of a seam when the tank is long and of small diameter.

However, as it is not a matter on which strength depends, it has been entirely omitted from the code, and left to the manufacturer to work out.

The limit of 100 lb. pressure is not reasonable because there is no greater stress on a weld in a 10 in. shell at 200 lb. pressure than in one 20 in. diameter at 100 lb., and because fiber stress is what governs the strength, and not pressure. Also as the maximum fiber stress and maximum thickness are specified, this restriction has been omitted.

Nor is the restriction of longitudinal seams to air vessels based on any engineering reason. Content has no bearing on design, if the pressure exerted by the content be known. If it be not known, it must be determined before a design can be made. Excess pressure is always taken care of by safety valves or similar devices, and never by making a tank heavy enough to stand any possible pressure that might be generated in it. Also for a given pressure the fiber stress is the same for any content, and if the latter be dangerous, the local authorities should see that enough efficient safety devices are applied to remove the danger. This is not a function of the code, because it is impossible for it to provide for all possible conditions. The general principles given in the A.S.M.E. code, in Sections U2 to U10 go about as far as is possible in regard to safety devices.

The restriction of contents to air has therefore been omitted.

Section U74 refers to convex heads, but its meaning is not at all clear as to the desired construction, though this could be easily remedied. But the requirement that the shell end shall be constricted is an entirely unnecessary burden, because there is no evidence that it adds to the strength. On the contrary the treatment needed to do the crimping may cause injury to the weld. It is further evident that unless there is an exact fit between the head and shell the stress is on the weld in any case, it being in shear up to the yield point. Prof. Roark gives a very good analysis of the stresses in this form of joint, in the paper referred to.

There may be no objection to an engineer specifying such a con-

struction, but it should not be mandatory and therefore has been omitted from the code.

Section U79 provides that defective sections of a weld may be repaired provided the value of the sheet has not been definitely lowered. This is impossible of enforcement, because there is no way of determining the value of the sheet. The requirement should be omitted. The entire section has been omitted as it is unnecessary.

SAMPLE

Specification for Fusion Welded Tank 60 in. Diameter. 20 ft. Long, for a Working Pressure of 200 lb. per sq. in.

1. The tank shall be made in accordance with these specifications and the drawings attached thereto, and in accordance with the laws of the State and municipality in which it is to be operated. Unless otherwise specified it shall conform to the attached code for unfired pressure vessels.

2. The plate shall be of firebox quality made by the open-hearth process, and shall be of the following chemical composition:

Carbon	.15% max.
Manganese	.30% to .60%
Phosphorus not over	.05%
Sulphur not over	.05%

It shall have a maximum tensile strength of 56,000 lb. per sq. in. With these exceptions it shall conform to Sections S-5 to S-17 of the A.S.M.E. Power Boiler Code, and to the weight requirements of A.S.T.M. Spec. A70-24.

3. The welds shall be made by the oxyacetylene welding process.

4. All bevels shall be made by machining where possible. If it is necessary to trim or bevel plates with a cutting torch, all scale shall be removed down to clean metal. All surfaces to be welded shall be thoroughly cleaned before welding.

5. The welding rod shall be of nickel steel to meet A.W.S. specifications, or of such other composition as will give practically equal weld strength and ductility, and that will meet the engineer's approval. The use of ordinary low carbon steel rod will not be permitted.

6. If approved by the engineer, the contractor may increase the number of girth seams to suit the size of sheets obtainable.

7. The length and radius of fillet welds shall conform to the note to Fig. U3 of the code.

8. In case a weld is found defective at any time during the test, it may be repaired as follows: pinholes shall not be calked, but may be welded up if the surrounding metal is properly preheated. If a crack of any length appears in the welds at any time during the construction or test of the tank, it may be rewelded provided it is not more than 3 in. long, that there is not more than one to six feet of seam, that the weld metal along the crack is entirely

removed, and that the surrounding metal is properly preheated. A general sweating of the weld under test may be repaired only by entire rebuilding of the vessel after all the weld metal has been entirely removed.

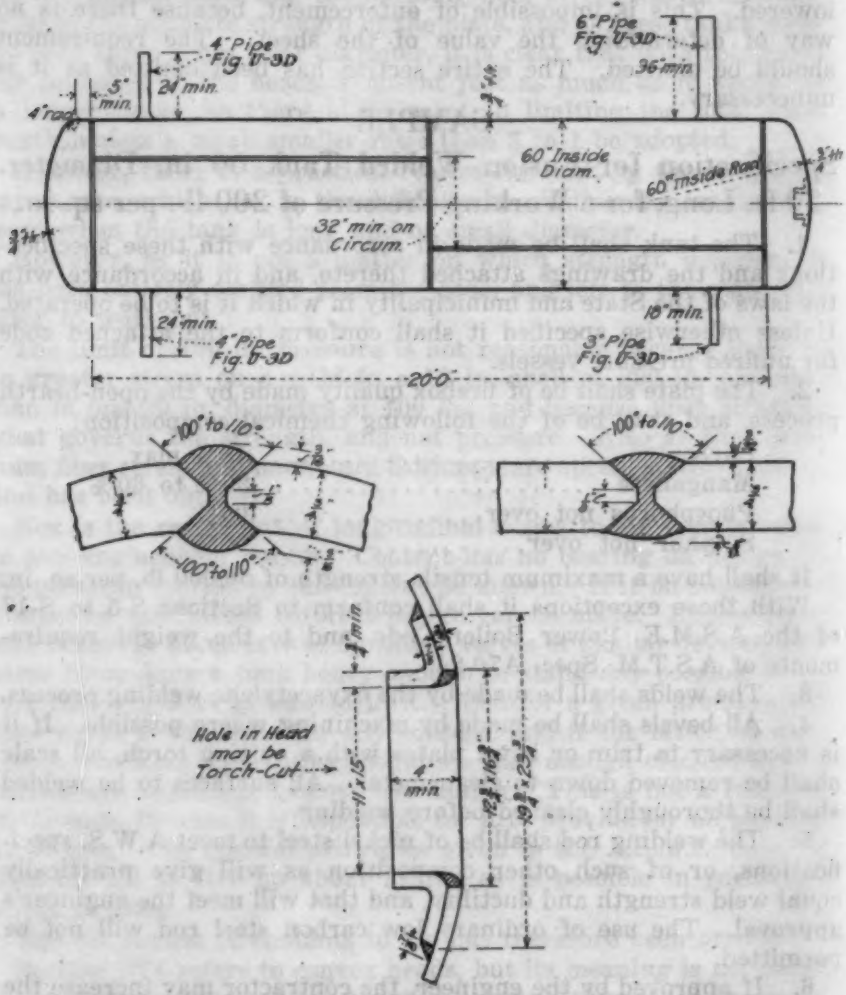


Fig. 9. Pressure vessel for 250 lb. per sq. in. working pressure

After repairs have been made, the vessel shall again be tested. Rewelding may be done only once. Failure to pass the secon i test shall reject the tank.

Selected Bibliography

Selection and Testing of Welders. "Selection of Qualified Welders," by Herman Ullmer. Journal. American Welding Society, July, 1925.

Physical Properties of Welds. "High Strength Welds," by J. R. Dawson. Journal American Welding Society, Oct., 1925.

Reliability of Welds. "Welding Locomotive Frames," by J. H. Chancey. Journal American Welding Society, July, 1925.

Design of Joints. "Welded Pressure Vessels." Bulletin No. 5, American Welding Society.

Precautions and Safe Practices. "Safety Engineering." Aug., 1925.

"Testing the Finished Weld," by S. W. Miller; Journal American Welding Society, Nov., 1925.

The Nature of the Weld Metal

A. Metallurgical Considerations. Papers by S. W. Miller.

B. Effect of Cutting Flame on Steel, by E. E. Thum; Iron Age, May 14, 1925.

Major Applications of Oxy-Acetylene Welding

A. Welding of Power Plant Piping, A. W. Moulder; Journal American Welding Society, October, 1925.

B. Oil and Gas Trunk Lines, N. E. Wagner; Proceedings International Acetylene Association, 1922.

C. Bronze Welding of Cast Iron Pipe, H. R. Swartley, Jr. American Gas Association, Proceedings, 1925.

D. Sheet Metal Welding, by T. C. Fetherston. The Linde Air Products Company, 1925.

E. Welding of 5/16 Plate. "Pipe Steel Shipped Flat, Then Rolled and Welded," by C. A. P. Duffie; Eng. News-Record; Nov. 26, 1925.

F. Welding of Heavy Plate. "Largest Oxy-Acetylene Welded Equipment Ever Built," by R. R. Orwig; Acetylene Journal, January, 1924.

G. Effect of Oxy-Acetylene on Steel Foundry Practice, by R. W. Thomas; National Acetylene Association, 1925.

H. Production Welding on Iron Castings. The Foundry; Nov. 15, 1924.

I. Salvage and Reclamation of Aluminum Alloy Castings, by R. J. Anderson and M. E. Boyd. American Foundrymen's Association; October, 1924.

J. Cutting Manufacturing Costs by Means of the Oxy-Acetylene Blowpipe, G. E. Hogemann. Management and Administration; November, 1924.

Electric Arc Welding Applications

Fusion in Arc Welding, by O. H. Eschholz. Transactions of the American Institute of Electrical Engineers for 1919, part 1, page 121.

Inspection of Metallic Electrode Arc Welds, by O. H. Eschholz. Railway Mechanical Engineer for July, 1918.

Physical Characteristics of Arc Metal, by O. H. Eschholz, in Power, for Feb. 15, 1921.

Forging of Arc Deposited Metal and Arc Welds, by O. H. Eschholz. Page 26 of the Welding Engineer for August, 1921.

Welding Pressure Vessels, by Andrew Oliver; page 28 of the Welding Engineer for February, 1921.

Arc Welding of Steel Structures, by F. P. McKibben; page 24, Journal of American Welding Society, February, 1923.

Applications of Arc Welding to Ship Construction, by E. H. Ewertz, from Marine Engineering and Shipping Age, for February, 1924.

Welding Large Storage Tanks, by Harold C. Price. Transactions of the American Institute of Mining and Metallurgical Engineers, for June, 1924.

Electric Arc Welding on Steam Locomotive, by W. M. B. Brady; page 687 of the G. E. Review for October, 1924.

All-Welded Gas Holder in Australia, by C. H. S. Tupholme; page 38 of the Welding Engineer for April, 1925.

Shell and Tube Type Ammonia Condensers, Design and Method of Construction, by L. H. Burkhart, in Refrigerating Engineering, for July, 1925.

Automatic Arc Welding and Tank Construction, by W. L. Warner, in the American Machinist, for Oct. 22 and 29, 1925.

Welding Mild Steel, by H. M. Hobart, in the 1919 Transactions, Part I, of the American Institute of Electrical Engineers, page 63.

CURRENT WELDING LITERATURE

Aluminum Welding, W. Peukert, Brit. Pat. 239412. Ill. Off. Jnl. (Oct. 28, 1925), p. 489.

Are Welded Pressure Tanks Safe? J. C. Lincoln, Power (Jan. 19, 1926), Vol. 63, pp. 109-110.

Arc Welding, Electric, E. C. R. Marks, Brit. Pat. 239291. Ill. Off. Jnl. (Oct. 28, 1925), pp. 4850-1.

Arc Welding, Electrode for, C. J. Holslag, U. S. Pat. 1559875. Off. Gaz. (Nov. 3, 1925), Vol. 340, p. 159.

Arc Welding Fans and Blowers, J. B. Flock, The Welding Engineer (January, 1926), Vol. 11, pp. 31-32.

Arc Welding, Method of and Means for Electric Welding, A. E. Puige, U. S. Pat. 1556360. Off. Gaz. (Oct. 27, 1925), Vol. 339, pp. 1026-7.

Arc Welding, New Aspects of Electric, Neue Ausichten Zur Elektrischen Lichtbogenschweisung, P. Flamm, Autog. Metallbearb. (Sept. 15, 1925), Vol. 18, pp. 273-4.

Arc Welding in the Building Industry, The Welding Engineer (January, 1926), Vol. 11, pp. 19-22. Static, Fatigue, Shock.

Arc Welding in Tank Construction, W. L. Warner, American Machinist (Oct. 22, 1925), Vol. 63, pp. 643-5.

Arc Welding in Manufacture, Use of, M. A. Atuesta, Engineering World (November, 1925), Vol. 27, pp. 281-2.

Arc Welding May Be Applied to Many Phases of Oil Industry, H. R. Dralle, Oil and Gas Journal (Oct. 29, 1925), Vol. 24, pp. 54-113. Gasolene Driven Engines.

Arc Welding Reduces Maintenance Costs, A. M. Candy, Electric Railway Journal (December, 1925).

Arc Welding Systems, British Thomson-Houston Co., Brit. Pat. 237275. Ill. Off. Jnl. (Sept. 16, 1925), Vol. 53, p. 4106.

Autogenous Welding of Copper by the Oxy-Acetylene Process, A. Eyles, American Machinist (Dec. 31, 1925).

Bronze Welding of Cast Iron Pipe, Iron Age (Nov. 26, 1925), Vol. 116, pp. 1465-6. Process advantages for centrifugally cast pipe; scientific control of welding operations, oxy-acetylene cutting helps foundry operation.

Cutting and Welding Torch, Power (Jan. 26, 1926), Vol. 63, p. 149.

Cutting Salamander and Heavy Masses of Iron with an Oxygen Lance, E. E. Thum, Blast, Furnaces and Steel Plant (January, 1926).

Effect of Heat of Bronze Welding on Cast Iron Pipe, A. R. Lytle, Acetylene Journal (January, 1926), Vol. 27, pp. 325-338.

Electric Welding Apparatus, W. R. Hume, N. Z. Pat. 53400. Pat. Off. Jnl. (Oct. 8, 1925), Vol. 14, pp. 5-36-7.

Electric Welding Costs, Electrical World (Jan. 23, 1926), Vol. 87, p. 207.

Electric Welding Mechanism, E. W. P. Smith, U. S. Pat. 1555166. Off. Gaz. (Sept. 29, 1925), Vol. 338, p. 1069.

Influence of Oxy-Acetylene Cutting on Steel Foundry Practice, R. W. Thomas, Acetylene Journal (January, 1926), Vol. 27, pp. 329, 334.

Instructions for Welding Pipe Lines, Electrical World (Jan. 9, 1926), Vol. 87, p. 102.

Manufacture of Oxygen, A. Edgar Knowles, The Welding Journal, London, (December, 1925).

Oxygen and Acetylene Piping, W. A. Slack, The Welding Engineer (January, 1926), Vol. 11, pp. 33-34. Good planning means fewer changes in layout; welding should be separate department; provide adequate pipe lines; location of generator and manifolds; pipe lines should drain back; preserve all survey data; welded lines require wrought iron pipe.

Procedure Control in Welding, L. E. Ogden, The Welding Engineer (January, 1926), Vol. 11, pp. 29-30. Every process controlled and supervised; good welding requires organization; procedure controls are for supervisors; a check on the welders; selection and inspection of the material; design and layout of the welded joint; preparation of the piece for welding; welding technique; inspection of welding and test of completed joint; applicable to all welding jobs.

Rails, Method of an Apparatus for Welding, E. Begtrup, U. S. Pat. 1556402. Off. Gaz. (Oct. 6, 1925), Vol. 339, p. 180.

Rebuilding Oil Field Tanks, D. W. Moore, Welding Engineer (January, 1926), Vol. 11, pp. 25-28. Patch bolting is a slow process; old material used for new tanks; how welded tanks are assembled; three pinholes in fifteen tanks.

Safety Department Approves Welding, the Welding Engineer (January, 1926), Vol. 11, pp. 35-36.

Stampings Assembled by Welding, L. S. Love, Iron Age (Jan. 14, 1926).

Welded Display Stands Are Sanitary, The Welding Engineer (January, 1926), Vol. 11, p. 37.

Welded 1650 Feet Underground, J. J. Burton, The Welding Engineer (January, 1926), Vol. 11, pp. 39-40.

Welding a Bull Dozer Frame, A. W. Young, The Welding Engineer (January, 1926), Vol. 11, pp. 38-39.

Welding Aids in Power Plant Maintenance, S. E. Dockstadter, Electrical World (Jan. 16, 1926), Vol. 87, p. 154.

Welding, Economical Repairs by, A. M. Candy, Iron Age (Nov. 12, 1925), Vol. 116, pp. 1307-9. Teeth of large pinions built up; welding department advisable.

Welding, Progress in 1925, W. Spraragen, Canadian Machinery and Manufacturing News (Dec. 31, 1925), Vol. 34, p. 154. Developments of year; merits of apparatus; research profitable; welding a profitable tool.

Welding and Cutting Torch in the Power Plant, L. A. Cowles, Power (Jan. 26, 1926), Vol. 63, pp. 146-148.

Welding Methods in the Engineering Industry, Modern. Wedemeyer, Engineering Progress (October, 1925), Vol. 6, pp. 321-6. Autogenous, thermite, electric arc and electric resistance welding; autogenous cutting.

Welding Progress in 1925, Joseph Cane, Canadian Machinery and Manufacturing News (Dec. 31, 1925), Vol. 34, pp. 127-8.

Welding Rods, Western Company Manufactures New Type. M. C. Smith, Western Machinery World (November, 1925), Vol. 16, pp. 452-3, 459.

Welding Tips on Edge Tools, Railway Journal (January, 1926). Vol. 32, p. 28.

World's Greatest Planes Are Welded, Donald W. Douglas, Acetylene Journal (January, 1926), Vol. 27, pp. 346, 348.

Year's Progress in Electric Welding, R. E. Smythies, Canadian Machinery and Manufacturing News (Dec. 31, 1926), Vol. 34, pp. 127. Admit it's coming; text books of tomorrow.

ACETYLENE JOURNAL

Established 1899

A monthly publication devoted to gas welding and cutting and other uses of the gases produced by this Industry.

If you are engaged in gas welding, or interested in any capacity in the Industry, you ought to be a reader of the ACETYLENE JOURNAL.

Its reading pages are **all** devoted to the promotion of **your** business. They will help you solve the many problems in repairing broken machinery, manufacturing new articles, and increasing production in your plant. It is edited and contributed to by the best authorities in gas welding and cutting. Should you have difficulty on any welding job, a letter written to the editor describing the trouble will bring you immediate advice.

Subscribe Now. Get in touch with the developments of the process and the benefits derived therefrom. Subscription price $2.00 a year.

A sample copy will be mailed on request

STUART PLUMLEY, Managing Editor

ACETYLENE JOURNAL PUBLISHING COMPANY

53 W. Jackson Blvd. **Chicago, Ill.**

Member Associated Business Papers, Inc.

The Welding Engineer

Member Audit Bureau of Circulations

FOUNDED BY L. B. MACKENZIE, 1916

"Take the Guess Work Out of Welding"

AN old slogan around the office of *The Welding Engineer*, but still one which cannot be emphasized too much. In your plant there is a man who needs timely, accurate and practical information about welding. See that he gets *The Welding Engineer* regularly. Subscribe now.

No matter what your welding problem may be, *The Welding Engineer* is the best source of information available. Its pages discuss, monthly, every phase of welding. One idea from one issue will more than pay for a year's subscription to this valuable publication. The value of the reading matter is assured for the best welding authorities in America are regular contributors.

Arc Welding, Electric Butt, Spot and Seam Welding, Oxy-Acetylene and the Thermit System, in fact every known process of joining metals is discussed. Our Buyers' Index reflects the progressiveness of America's first manufacturers.

Price $3.00 in the United States and Canada; $4.00 Abroad

Sample Copy Sent Free Upon Request

H. S. CARD, EDITOR

The Welding Engineer—608 S. Dearborn Street, Chicago, Ill.

The Standard of Quality in Gas Welding and Cutting Equipment

The Torchweld Trademark, representing an original and distinctive development in the Oxy-Acetylene field, insures

SAFETY—ECONOMY—DEPENDABILITY

to all users of Torchweld Gas Welding and Cutting Equipment.

Send for Catalog No. 23-J

TORCHWELD EQUIPMENT COMPANY

224 No. Carpenter St. Chicago, Ill.

YES! FOR UNIFORM AND RELIABLE WELDING RESULTS

SPECIFY HOLLUP WELDING WIRE

WANAMAKER COATED AND **REX** BARE ELECTRODES

REX GAS WELDING RODS — REX ACCESSORIES

Write for literature and free samples.

Manufactured by

C. H. HOLLUP CORPORATION

3333 W. 48th PLACE CHICAGO

Bound Volumes

Journal of the

American Welding Society—1925

A limited number of copies of the JOURNAL for the year 1925 are now available in attractive book form. This bound volume includes subject and authors indexes of all technical papers appearing therein.

As in previous years, these bound volumes are sold to members at $5.00 per copy. A few volumes are still left for the years 1922, 1923 and 1924.

Orders should be placed at once with the Secretary of the Society.

Essentials for Safe and Reliable Electric Arc Welding

WANAMAKER COATED ELECTRODES and TECOR ACCESSORIES

Write for Booklet

TRANSPORTATION ENGINEERING CORPORATION

269—37th STREET
BROOKLYN, N. Y.

327 S. LA SALLE STREET
CHICAGO

REGO

"LOWER OXYGEN PRESSURE"

Welding and Cutting Equipment

WRITE FOR CATALOG NO. 37

THE BASTIAN-BLESSING COMPANY

252 E. Ontario St., Chicago, Ill.

SWEDOX

WELDING RODS, WIRES and ELECTRODES

A Grade for Every Purpose

NONOX SWEDOX
LEKTROX SWEDOX
CASTOX
ARC CARBOX
GAS CARBOX
VANOX

STEELKOTE
LEKKOTE
CYLKOTE
MANKOTE
RAILKOTE

TENSKOTE
DUCTKOTE
DUCTILOX
NICKOX
RAILOX

KROMOX
MANGANOX
ALUMINOX
DRAWN ALUMINUM
BRAZOX

BRONZOX
BRONZKOTE
TOBIN BRONZE
MANGANESE BRONZE
MONEL METAL

TENSILOX
KROMKOTE
NICKOTE
VANKOTE
FLUXES

SEND FOR TESTING SAMPLE

We want every welder in the country—big or small—to be convinced of the *specialized superiorities* of SWEDOX products. We know that a trial *will* convince you. Hence the free offer. Try SWEDOX on your next welding job at our expense.

CHICAGO, ILL.
4545 S. Western Blvd.
Phone:
LaFayette 8500

Central Steel & Wire Company

DETROIT, MICH.
5001 Bellevue Ave.
Phone:
Lincoln 6700

"We Ship the Same Day"

Weldite

Iron and Mild Steel Rods

Are offered Copper Coated for Gas Welding and Bare or Flux Coated for Electric Welding.

THE WELDITE LINE

WELDITE No. 6—A very pure iron conforming to the American Welding Society specifications G-1 A and E-1 A.

WELDITE No. 10—A slightly higher carbon iron representing the very best in a general utility rod. Especially recommended for production work on tanks, boilers and sheet steel fabrication of all kinds.

WELDITE No. 18—A mild steel conforming to the American Welding Society specifications G-1 B and E-1 B.

WELDITE No. 85—A high carbon steel very useful in railroad and oil field work.

WELDITE No. 110—An extremely high carbon steel conforming to the American Welding Society specification E-1 C.

A catalog describing each rod in detail will be mailed upon request

BACK of every WELDITE Rod are five years of painstaking experimental work conducted in our own Research Laboratory. The results are evident in the welding characteristics and uniformity of each rod in the WELDITE Line. They make better welds.

TO WELDING ROD AND SUPPLY SALESMEN

Much desirable territory is available for experienced welding supply salesmen under our agency plan. Correspondence is invited from men who want to establish a business of their own.

CHICAGO STEEL & WIRE CO.

103rd Street & Torrence Avenue, Chicago, Ill.

Manufacturers

"I'll Tell You Why I Like Wilson Wire"

Rugged—Simple

The new Wilson Type S Welding Machine is another distinctive Wilson achievement in the development of electric arc welding. Its self-excited generator, its easy-to-set current, its easy-to-strike and easy-to-maintain arc, its fast work and its *rugged* and *simple* construction—these are some of the features that make Wilson machines the decided choice of welders in practically every industry. Various models include motor-driven, gasoline-engine driven and belt-driven machines in capacities from 75 to 250 amperes. Write for prices and full information. There is no obligation.

"You know how it is. If there's any trouble with a weld—if it isn't right—why, the blame comes right back to us fellows who do the work. So you see, I don't want to take any chances. I want Wilson Wire. I *know* IT'S alright—it runs uniform all the way through. And that's true of every grade of Wilson Wire. You know Wilson has a grade for every kind of welding."

And he is right, why should he be blamed for poor welding when it's the fault of the wire? Good welders want to protect their reputations, so they want Wilson Wire. Why not give it to them? There is no economy in inferior wires. And among the different Wilson grades, there is just the right analysis of wire for every kind of metal you desire to weld. Simply tell Wilson or a Wilson distributor what class of welding you are doing. You can depend upon the uniformity and flowing quality of every grade (analysis) of Wilson Wire. Each is designated by color: Hence Wilson "Color-tipt" Welding Wire. Write today for prices and samples, indicating the kind of metal you desire to weld.

WILSON WELDER & METALS CO. INC., WILSON BLDG., HOBOKEN, NEW JERSEY

WILSON

WELDING MACHINES AND WELDING WIRE

UNION CARBIDE

World's Best Quality - Highest Gas Yield
Always Uniform - Always Dependable

Packed in Blue and Gray Drums

We have Warehouses in 175 Cities

The product of the originators and developers of the carbide and acetylene industry

QUALITY assured by more than a quarter of a century of experience in selecting raw materials and in perfecting laboratory practice and works processes.

The faithfully sustained quality compels recognition of the economies which go with it.

Union Carbide will keep for years in the original package without deterioration.

Our remarkable nation-wide service and distributing system makes Union Carbide quickly available everywhere.

There is a Union Carbide warehouse near you. Shipment is made same day your order is received.

We supply Union Carbide in Generator sizes—direct to consumer—at factory prices.

Our Blue and Gray Drum is recognized throughout the world, as a symbol denoting Best Grade Carbide, Highest Gas Value, Uniform Dependable Quality and Purest Gas.

UNION CARBIDE SALES COMPANY

Principal Offices: Carbide and Carbon Bldg., New York, N.Y.
Peoples Gas Building, Chicago, Ill. Balfour Building, San Francisco, Calif.

Why buy Linde Oxygen?

THAT'S a fair question. It deserves an answer. And there must be some good answers or Linde would not dominate the oxygen field.

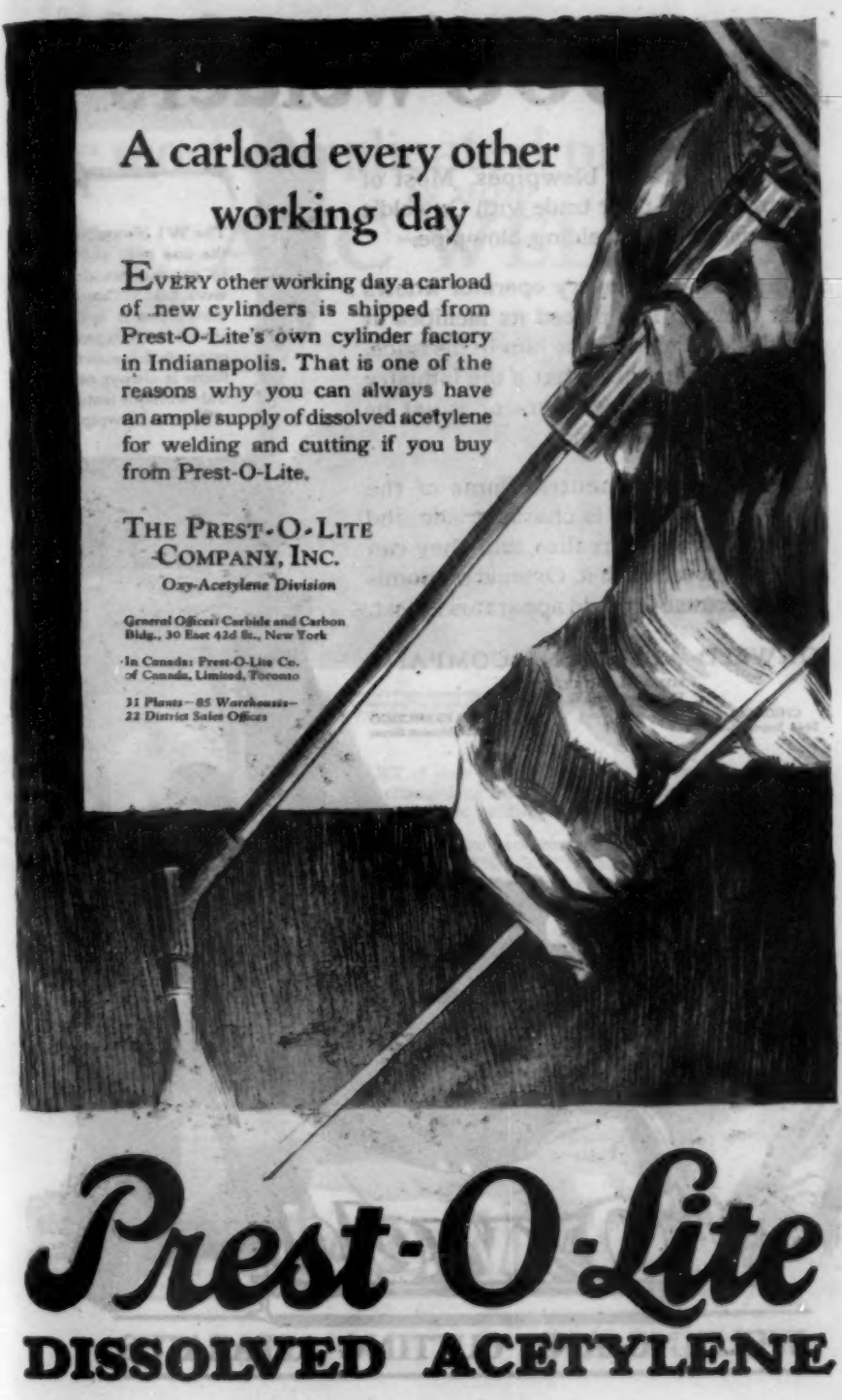
Of course there is no better oxygen on the market. The name Linde has always stood for a uniform product of highest purity, for dependable supply and for prompt delivery. But these are only three reasons for Linde's leadership.

Linde service goes much deeper than that. A competent staff of field service men operating out of each district office stand ready to give you practical help and engineering advice. Our research laboratories are constantly making available through this service new applications and perfected methods of the oxy-acetylene process.

The newest additions to Linde service are Procedure Controls. They are detailed, carefully prepared instructions that enable an organization to carry out even difficult welding operations practically unaided.

THE LINDE AIR PRODUCTS COMPANY
General Offices:
Carbide and Carbon Building, 30 East 42d Street, New York
37 PLANTS—93 WAREHOUSES

To construct a welded storage tank successfully requires much more than skilled workmanship, although this is highly essential. Sound metal, efficient equipment, proper design and preparation of the joints, intelligent inspection and adequate testing all play an important part. The Linde Procedure Control on welding a storage tank gives detailed information on all necessary points.


A carload every other working day
EVERY other working day a carload of new cylinders is shipped from Prest-O-Lite's own cylinder factory in Indianapolis. That is one of the reasons why you can always have an ample supply of dissolved acetylene for welding and cutting if you buy from Prest-O-Lite.
THE PREST-O-LITE COMPANY, INC.
Oxy-Acetylene Division
General Offices: Carbide and Carbon Bldg., 30 East 42d St., New York
In Canada: Prest-O-Lite Co. of Canada, Limited, Toronto
31 Plants—85 Warehouses—22 District Sales Offices
Prest-O-Lite
DISSOLVED ACETYLENE

100,000 welders

KNOW Oxweld blowpipes. Most of them learned their trade with Oxweld's old reliable W1 welding blowpipe.

More than that, every operator knows that Oxweld has placed its facilities at his disposal to advance him in his trade. For Oxweld realizes that if the industry is to progress the operator must be encouraged to advance.

The soft, even, neutral flame of the Oxweld blowpipe is characteristic and unique. Welders realize that they can do better work with it. Oxweld predominates because Oxweld apparatus is best.

The W1 blowpipe is the one best suited to general welding work. Like all Oxweld blowpipes it is designed on the injector principle. It means the flame is always neutral—a unique feature of Oxweld blowpipes.

OXWELD ACETYLENE COMPANY

LONG ISLAND CITY, N. Y.
Thompson Ave. & Orton St.

CHICAGO
3442 Jasper Place

SAN FRANCISCO
1030 Mission Street

Oxweld

WELDING AND CUTTING APPARATUS

The most complicated pipe work *is now* ARC-WELDED

Type WD Arc Welders

Reliability, heavy duty, speed, and simplicity are outstanding features of the G-E Type WD Arc Welders which are making them the most popular and widely used line in the welding field.

Arc welded offtake connections and collecting manifold for conveying hot gases from water gas machines directly to relief holder

ANY PART of your piping system can be installed, connected, changed, or repaired to the best advantage and at the least cost by arc welding methods.

Simplify your pipe line problems! Cut out the separate fabrication of nipples, T's, L's, Y's, and manifolds. Eliminate time-taking operations such as elaborate template work, layout, punching, drilling, reaming, and riveting.

With a G-E Arc Welder in your plant, the installation and maintenance of piping systems become a minor problem of plant management. Expenses are greatly reduced, much valuable time is saved, and the welds are pressure tight with a permanent metallic seal.

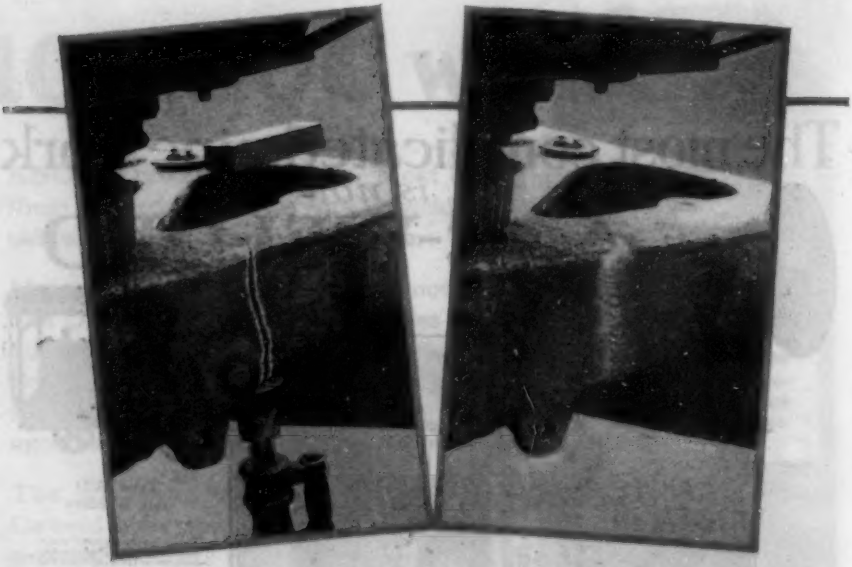
The G-E Arc Welder is the outstanding choice of the foremost pipe fabricators in the country. This preference exists because the genuine value of the G-E Arc Welder, and the service that accompanies it, are unequalled anywhere.

Ask your nearest G-E sales office for advice on the welding sets best fitted for your particular needs.

In addition to a complete line of arc welders, General Electric manufactures welding electrode wire. The exceptional welds obtained from this wire are causing its general adoption wherever welding is done.

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES



Back on the job in three hours!

TOBIN Bronze Welding Rods made possible the welding of this cast iron steam shovel frame—in three hours—without dismantling or pre-heating.

If repairs had been made with iron welding rods, the delay and expense of dismantling, pre-heating and re-assembling would have been unavoidable.

Broken or cracked castings may be restored to their former usefulness—at small cost—by welding with Tobin Bronze, and the resulting weld will be stronger than the original cast iron.

Tobin Bronze Rods, manufactured solely by The American Brass Company, can be secured from leading Distributors.

Descriptive pamphlet, including tables of weights, melting points, also suggestions for welding with Tobin Bronze, sent upon request.

THE AMERICAN BRASS COMPANY

GENERAL OFFICES: WATERBURY, CONNECTICUT

TOBIN BRONZE

REG. U.S. PAT. OFF.

WELDING RODS

"PROCESSED"

The cost sheets *tell the tale!*

Users who have standardized on Page-Armco and Steel "Processed" Welding Wire and Electrodes find their cost sheets showing a pleasing reduction in the cost of handling particular types of work.

This is due to the exclusive Page method of "Processing" all wire and electrodes to meet the exact requirements of the class of work to which they will be subjected.

Regardless of the job you will find a correct grade of Page "Processed" Wire, or Electrode to do it more efficiently and economically—to save your welders' time and eliminate spoiled work.

Page Mild Steel Gas Welding Wire, and Electrodes, Page-Armco Wire and Electrodes and Page High Carbon Wire and Electrodes are rapidly being specified as standard. Place them to the most severe tests and watch your cost sheets show a real saving. Let us prove this to you. Write today for interesting literature and samples. No obligation.

PAGE STEEL & WIRE COMPANY

An Associate Company of the American Chain Company, Inc.

Bridgeport, Connecticut

District Sales Offices:

Chicago New York Pittsburgh San Francisco

PAGE-ARMCO

PROCESSED

Welding Wire and Electrodes

They say

"It produces a wonderful, sound, compact and soft weld . . . most satisfactory results from first."

—*—

"Highly satisfactory as to performance and upkeep."

—*—

"We have 5 Lincolns . . . thoroughly satisfied with service rendered by machines and your company."

—*—

"In its service it has given entire satisfaction and practically no trouble."

—*—

"It has never been necessary to make repairs for the first Lincoln purchased six years ago."

Before you settle on the type of machine— get the users viewpoint

Any Lincoln office below will put you in touch with a user near you whose experience covers many types of welders. Get his viewpoint based on experience.

Branch Offices
Baltimore
Boston
Buffalo
Charlotte, N. C.
Chicago
Cincinnati
Detroit
Des Moines
Grand Rapids

The Lincoln Electric Co.

General Offices and Factory:
Cleveland, Ohio

The Lincoln Electric Co. of Canada, Ltd., Toronto-Montreal
European Representatives: Allen-Liversidge, Ltd., London

Branch Offices
Indianapolis
Milwaukee
Minneapolis
New York City
Philadelphia
Pittsburgh
Rochester
St. Louis

Distributing agencies in all principal cities.

Exclusive Agencies with Stock:
Ft. Worth, Texas
Los Angeles
New Orleans
San Francisco

LINCOLN "Stable Arc" WELDER

Welding
ROEBLING
Wire

conforms to the specifications of the American Welding Society. Exacting tests have proven that it possesses those qualities essential to good welding.

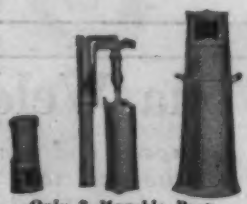
John A. Roebling's Sons Company
Trenton, N. J.

SENSATION OF 1926

CARBIC MODEL XI

THE SMALLEST EFFICIENTLY OPERATED GENERATOR IN THE WORLD. WEIGHS EMPTY ONLY 45 LBS.

CAPABLE OF WELDING METAL THICKNESS UP TO ONE-HALF INCH. SUPPLIES ACETYLENE FOR ALL STANDARD CARBIC CUTTING NOZZLES.



Only 3 Movable Parts

Carbic Manufacturing Company

NEW YORK - DULUTH, MINN. - LOS ANGELES

Warehouses and Representatives in Other Principal Cities

THERMIT WELDING

For heavy welding operations in all fields

Railroad Industrial Marine

METAL & THERMIT CORPORATION

120 Broadway, New York

Pittsburgh Chicago Boston S. San Francisco Toronto

MILBURN

Efficiency and economy of gases are achieved in Milburn Welding and Cutting Apparatus.

Welding Torches Acetylene Generators Regulators
Cutting Torches Compressing Plants Accessories

Send for Catalog No. 354

THE ALEXANDER MILBURN COMPANY

1416-28 W. Baltimore Street Baltimore, Md.

Una Welding ***offers not only***

speed and economy in joining metals, but also the necessary strength, toughness and resistance to impact of the weld metal.

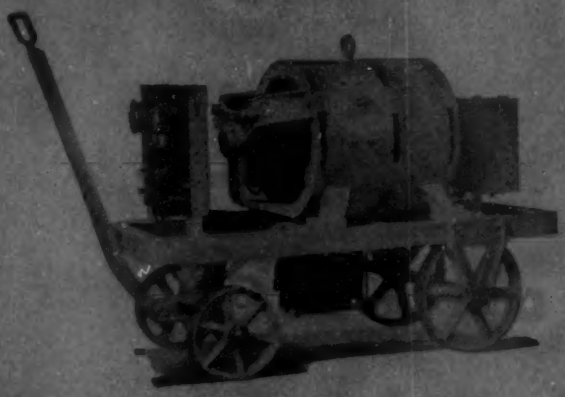
UNA WELDING AND BONDING COMPANY

CLEVELAND, **UNA** OHIO

Welding Processes
Welding Rods

A.B.-D.C. Welders
Welding Supplies

A WELDING MACHINE YOU CAN DEPEND UPON UNDER MOST SEVERE CONDITIONS



Portable Volume Arc Welder on Portable Truck

Compact—No coupling to get out of alignment.

No Exciter—The generator is self-exciting.

Excellent welding characteristics throughout entire range.

Micrometer adjustment of welding current from 50 to 300 Amperes for continuous service.

Complete information on request.

BURKE ELECTRIC COMPANY

ERIE, PA.

Service Sales Offices

NEW YORK CHICAGO PHILADELPHIA PITTSBURGH
CLEVELAND DETROIT BUFFALO

Sales Agencies

CINCINNATI — UNDERWOOD ELEC. CO.
KANSAS CITY — W. T. OSBORN
MILWAUKEE — FRED H. DORNER
TULSA — J. E. ARNOLD
AKRON — BERTHOLD ELECTRIC & ENG'G. CO.
OMAHA — D. H. BRAYMER EQUIPMENT CO.

AIRCO GASES

WITH

Airco-Davis-Bournonville Apparatus
Airco-Davis-Bournonville Supplies
and Airco Engineering Assistance

AFFORD the complete cycle of service to the oxy-acetylene user and make possible the most efficient and profitable results, with oxygen, acetylene and carbide of maximum purity and welding and cutting apparatus of maximum performance.

Every Requirement
For Oxy-acetylene Welding
and Cutting

Airco Plants, Distributing Stations and Airco Repair Departments, located at most accessible shipping points throughout the United States, comprise 26 Oxygen Plants, 15 Acetylene Plants, 2 Calorene Plants, 2 Carbide Plants, 17 District Sales Offices, all owned and operated by

AIRCO
DAVIS
BOURNONVILLE

Airco District Offices

Birmingham, Ala.
2325 N. 29th Ave.
Boston, Mass.
122 Mt. Vernon St.
Buffalo, N. Y.
130 Grant St.
Chicago, Ill.
2324 S. Loomer St.
Cincinnati, Ohio
1219 W. 69th St.
Detroit, Mich.
7991 Hartwich St.
Emeryville, Cal.
Park Ave. and Halleck St.
Los Angeles, Cal.
1940 E. Vernon Ave.
Milwaukee, Wis.
1290 Forest Home Ave.
Minneapolis, Minn.
327 25th Ave., S. E.
New York, N. Y.
181 Pacific Ave., J. C., N. J.
Oklahoma City, Okla.
P. O. Box 1338
Philadelphia, Pa.
Allegheny and Germantown Ave.
Pittsburgh, Pa.
1116 Ridge Ave.
Richmond, Va.
10th and Marshall Sts.
St. Louis, Mo.
115 Plum St.
Seattle, Wash.
3622 E. Marginal Way

AIR REDUCTION SALES COMPANY

Manufacturer of

Airco Oxygen—Airco Acetylene—Airco Calorene—Airco Davis-Bournonville Welding and Cutting Apparatus and Supplies, Acetylene Generators, and Specially Designed Machines for Automatic Welding and Cutting—Airco National Carbide—Nitrogen, Argon and other Airco Atmospheric Gas Products

Office: 342 Madison Avenue, New York

67 Distributing Stations